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Site-Level Integration of Information Technologies in Construction: An Empirical Study of Information Technology Adoption

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Site-Level Integration of Information Technologies in Construction: An Empirical Study of Information Technology Adoption

by

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Thesis

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Dedication

This thesis is dedicated to my beloved family and friends for their unwavering love, support and encouragement.

To my mother and father, who have made me who I am today and continue to inspire me to do my best in all aspects of life.

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Abstract

Site-Level Integration of Information Technologies in Construction: An Empirical Study of Information Technology Adoption

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The availability of information technologies (IT) that can be harnessed to support construction projects at the site-level (e.g. tablets devices) continues to increase substantially. Most computer devices and IT resources today are designed for mobility, providing construction onsite personnel potential access to electronic resources and relevant information while on the construction site or in the construction field office; enabling the possibility of real-time data exchanges amongst various project entities, unrestricted by location. Recent industry literature has highlighted the benefits associated with the use of onsite emerging construction IT and, as a result, construction organizations are showing a strong interest in implementing these technologies to improve and develop more cost effective construction document management and communication processes. Despite the perceived benefits, the construction industry has been slow to adopt IT, particularly in the construction execution phase and, more

specifically, at the site-level. This research aims to analyze the industry's current state of construction field and office personnel's use and proficiency related to IT. This study also offers insight into the impacts the adoption of IT has on field personnel's onsite processes, and identifies industry-specific barriers associated with the adoption of IT. To extend the knowledge related to IT usage of project site-level personnel, the results of a survey, follow-up interview, and an IT training and evaluation study were reviewed. These tools helped to investigate and acquire data regarding site managers' and field engineers' technology-related competence, their applications of IT to produce work artefacts, and circumstances in which users and technology hinder the adoption of IT in construction. Collectively, an analysis of the results revealed that the construction industry's current state of IT adoption at the site level is more advanced than previously perceived; particularly with the use of basic technology and software tools. Furthermore, the results offer a foundation for determining "areas of improvement" for increased adoption of IT in an onsite environment. Industry business-related limitations and individual's technology proficiency currently present the prevalent barriers related to the hindrance of adoption. The inadequate effectiveness of IT to support field personnel's daily processes was also found to a be a contributory constraint.

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Chapter One: Introduction

Problem Statement

Construction onsite activities frequently require substantial information collection, analysis, and processing. Site-level personnel, employees required to be onsite to successfully fulfill their project-related tasks, have traditionally managed essential project data using paper-based methods (McCullouch, 1997). The development of construction oriented information technology (IT) applications to facilitate onsite data handling has been well-received within the construction industry. Recent literature surrounding this movement has been extensively promoted specifically regarding the development, deployment, and definitive site-level improvements IT may impose on engineering, construction, and information management practices.

Despite alleged industry approval, adoption and penetration of IT during the construction execution phase continues to be underwhelming, particularly at the site level (O'Connor et al., 2000; El-Mashaleh, 2006). Several studies have investigated the root cause for low adoption of IT and have concluded that people-related hindrances have been the primary source for the lack of onsite IT implementation. To-date, direct observational data to support these claims is sparse. Empirical evidence remains largely unavailable in regards to:

- Site-level personnel's current level of IT employment.
- Site-level personnel's proficiency associated with technology usage.
- The effects of computer-based systems on worker's construction activities.

Motive and Purpose

Regularly, unavailable or missing information on construction projects can be linked to delays and rework (Dong et al., 2006). To offset these issues, unique IT applications that focus on specific construction-related activities have been developed to allow a greater level of task efficiency and timely exchange of information. The introduction of mobile computing for construction execution services has had a significant impact on how these applications can be integrated into site-level work (Bowden, 2006). As a result, the industry is quickly recognizing site personnel as likely beneficiaries of IT to support their daily tasks (Olofsson & Emborg 2004; O'Brien et al., 2011). In spite of these perceived benefits, onsite adoption of these tools remains low. Unfortunately, few studies have examined the basis for this phenomenon.

Conventional industry knowledge often implies that there is a strong relationship between the low adoption of IT on construction sites and site-level personnel. In the past, technology academics and software vendors have speculated that the industry-related "technology push" would induce and govern adoption of innovative practices during construction execution; this ideal has yet to yield supportive results. Conversely, construction professionals have impressed upon the industry that more practical obstacles such as resistance to change and IT illiteracy by site-level personnel impede technology adoption (Kim, 2003). While technology adoption at construction sites appears to be inherently low, lack of direct empirical evidence exists to support the basis of such claims. To extend the use of IT at the site-level, the core issues associated with low adoption must be identified so that effective solutions may be researched and applied.

Through the collection of empirical evidence, this study aims to gauge and understand construction site-level personnel's current technology usage and competency, and determine the basis for the low adoption of IT at the site-level. The information provided also introduces tangible context that will allow an improved understanding of site-level barriers associated with IT adoption against previous viewpoints.

Research Scope

The subsequent study conducted a literature review of relevant research associated with available IT tools and practices in support of construction performance. Relevant literature was also examined to provide insight into the present state of technology usage from a global and construction industry perspective. Typical construction execution artefacts and resources related to site-level performance and practices were identified. Following, a survey was deployed. The survey required site-level personnel to gauge their current state of IT usage to develop task-specific artefects and indicate their skill level related to typical construction technology tools. A follow-up interview and an IT training and evaluation study were conducted to determine the effects of IT tool implementation, in lieu of paper-based methods, to support construction field personnel's activities.

Research Objectives

The primary objective of this research is to evaluate and understand the impacts, implementation requirements, and adoption of IT at the site level through the collection and analysis of empirical evidence. Specific objectives include:

- Investigate the current state of usage and skill-level of IT by site-level personnel in the construction industry compared to previous industry observations.
- Investigate the impact of IT when applied to site-level activities and identify potential barriers to the adoption of IT by site-level personnel in the construction industry compared to previous viewpoints.

Limitations

The limitations of this research project arise from the broad scope of information technologies that are currently offered to support construction information management and the inconsistency of technology usage on a project by project basis:

- The research focused on semi-automated technologies available for in-office and in-field data collection methods and disregarded fully-automated data collection systems.
- The data collected was analyzed on an industry wide basis and did not differentiate data collected by project or construction industry sector (i.e. commercial, industrial, or infrastructure).
- The "Field Personnel" survey and interview data collected was limited to Superintendents, Foremen, and Field Engineers. Field Inspectors and craft workers were omitted from this study.

Thesis Structure

This thesis is organized into six chapters and several appendices containing the results of the technology use and skill-level survey, follow-up interviews, and training and evaluation study packages used for data collection. Following this introductory section, Chapter Two provides a synopsis on the current use of IT in construction and perceived industry barriers related to the onsite adoption of IT. In Chapter Three, an explanation of the research methodology implemented to achieve the aforementioned objectives is provided. Chapter Four presents the results of the data collection tools. Chapter Five provides a discussion of the results pertaining to each research objective and question. In Chapter Six, conclusions and recommendations for future research are offered.

Chapter Two: Background Information

This section offers a synopsis on available literature pertaining to the various aspects that are currently influence the use of information technology at the construction site-level. First, the availability of information technologies for construction onsite practices are provided. Challenges related to the adoption and acceptance of IT in the construction industry, discussed by current literature, are then highlighted. Finally, attributes that have influenced other industries' adoption and acceptance of IT including IT proficiency and training are summarized.

Information Technologies for Onsite Construction Practices

The construction industry is highly fragmented and requires essential data exchanges between various entities (e.g. owner, project manager, contractor, etc.) to deliver a successful project (Chen and Kamara, 2011; Kim, 2003). As projects have become increasingly complex and client deliverables more challenging, information availability issues have correspondingly escalated (Dong et al., 2006). In fact, industry studies have indicated that 50-80% of the issues on construction sites can be accredited to missing or delayed information access (Howell and Ballard, 1997; Thomas et al., 1997).

Construction execution and site-level data collection typically revolves around design and specifications, project controls, quality control, safety, material management and project delivery activities. These activities require information sets that include chronological correspondence, memorandums, submittals, various control records, resource and inventory logs, and progress logs (Cox et al., 2002; Fiatech, 2012). To

develop the these information packages, site-level personnel rely on the use of artefacts to support their work (Fischer and Kunz, 2004; O'Brien et al. 2011). Artefacts are general purpose tools such as forms or spreadsheets. As technology surrounding the industry continues to evolve, there is an increasing desire for site-level personnel to utilize IT to develop these artefacts electronically.

The basic principal surrounding the use of electronic information exchanges at the site-level is referred to as web-based or web-enabled project management (Alshawi et al., 2003; Ward, 2004). Web-based project management (WBPM) requires a distinct onsite hardware structure and computerized data collection tools. The hardware structure generically consists of mobile technology (e.g. tablet or laptop), an onsite server system or internet connection, and a storage device (Chen et al. 2011; Dong et al., 2006). The data collection tools have been categorized into three key levels which are dependent on the range of automation provided (O'Connor et al., 2000):

- Level 1 encompasses traditional data collection methods. Traditional methods offers no electronic tools and conveys information on paper, making transmission possible only by fax or mail. Paper-based onsite construction processes have been found incapable of delivering just-in-time information and often cause information deficits (Chen and Kamara, 2011).
- Level 2 data collection methods provide the use of semi-automated electronic tools that can store information in standalone formats. The use of e-mail or web-based platforms support data exchanges at this level. Mobile devices are one of the more commonly used tools to support this level of automation, readily

providing site-level staff full sets of up-to-date construction documents (Eaton, 2012; Löfgren, 2007).

- Level 3 uses fully-automated devices for data collection and requires minimal support by human workers. Similar to Level 2, Level 3 uses electronic platforms to distribute and exchange information. Tools such as GPS, laser scanning, radio frequency identification, bar-coding, and wireless sensors are rapidly emerging and facilitating the task of automated data collection. (Dong et al. 2006; Gordon et al., 2005; Ward, 2004; Zhang et al., 2009)

Level 2 of WBPM has been the most comprehensively examined in terms of availability, use, and benefits, regarding data handling for site-level personnel's daily processes. At this level, mobile hardware, used in conjunction with software, is the foundation for onsite data collection. The software for these devices may be general use or discipline specific (Fischer and Kunz, 2004). General use software often consists of very generic and flexible electronic tools such as text processors or electronic spreadsheets that require formatting to meet end-users' needs. Discipline specific software are often created by a developer and have been structured to meet specific onsite requirements. In this respect, software interfaces can be developed to exclusively gather necessary process-specific data associated with site-level activities and tasks (e.g. punchlist management during project execution).

Improvements to communication and means of exchanging information significantly influence project performance (Nash et al., 2002). Recent literature has discussed the development and deployment of IT to support engineering and information

management processes at the site-level during construction execution (Alshawi et al, 2003; COMIT, 2003; Chen and Kamara, 2011; Kim, 2003). Other studies have provided direct definitive site-level IT improvements to onsite productivity, information availability, and information quality (Dong et al. 2006; DPR Construction and CIFE, 2009; Olofsson & Emborg, 2004). Emerging construction field office technologies such as web-based document management systems support improved information management and reduces the lead-time associated with data exchanges (Zarebidaki, 2013). These technological advances also improve timely decision-making capabilities by office administration (Becerik and Pollalis, 2006). Construction field access to the latest project documents and information, through the use of IT and automation systems, has been proven to minimize data related errors, reduce labor time, and eliminate rework. (Cox et al., 2002; Latista Technologies, Inc., 2011). The use of IT onsite enables a platform in which office and field personnel can readily exchange and communicate information in real-time.

Acceptance and Challenges Related to Technology in Construction

According to Chen et al. (2011), the use of IT at the site-level relies heavily on independent and dependent factors. Independent factors pertain to the users of the technology and the industry environment. These factors, particularly user-related issues, have high and consistent impacts on IT implementation in the capital projects industry (Kang, 2010). Streams of research surrounding construction IT have extensively investigated the independent factors related to IT usage, such as human-computer interaction and cognitive task analysis (O'Brien et al, 2011; Distefano and O'Brien, 2009).

Dependent factors involve available IT hardware and software applications. On occasion, the reluctance to accept IT has been a result of technology issues such as software interoperability, wireless connectivity, and deficiency in onsite security (Chen and Kamara, 2011; Kisiltas et al, 2008). In particular, IT usefulness, which is the ability of a technology to fulfill user needs and effectively improve their activities, has been problematic (Löfgren, 2007). Over time, many of these issues have been heavily researched and improved upon (Bluebeam, 2013; Dorgan, 2011; Kiziltas, 2008; Chen et al, 2011).

A study performed by Fiatech (2012) indicated that a general understanding of potential IT implementation benefits to improve construction execution processes currently exists in the industry. Despite user acknowledgement, penetration of IT at the site level remains difficult. Recent surveys have shown low adoption of IT during the construction execution phase to perform site-level tasks (e.g. O'Connor et al, 2000; El-Mashaleh et al, 2006). To-date, circumstantial evidence in the form public opinion has been offered to explain this circumstance. Critical barriers linked with low IT adoption have been attributed to onsite personnel, particularly older employees, and their reluctance to accept IT, resistance to change, and low IT literacy (Mitropoulus and Tatum, 2000; Kim, 2003; Ward, 2004). Currently, at large, the majority of these barriers have been speculative and offer minimal empirical data.

General Information on Technology Usage - Skill Level and Frequency of Use

The necessity of IT literacy (i.e. computer skill sets) to support industry IT adoption appears to be well-understood (Chen et al, 2011; Kang, 2010). However, construction industry research that offers observational data examining workers' abilities to utilize technology is lacking (Hewage and Ruwanpura, 2009). University and Healthcare studies that correspond to this topic are readily accessible; and specifically examine the impacts and use of IT resources in relation to user skill proficiency and adoption. A better understanding of technology adoption relationships within the construction industry may be achieved by reviewing and drawing feasible parallels to supplementary industry studies.

Limited IT skills encountered during several university studies demonstrated that low technology proficiency can deter or discourage students from utilizing electronic resources (Akande, 2011; Egberongbe, 2011; Ojo and Akande, 2005). Particularly, computer skills related to searching and finding information are essential (Brand-Gruwel and Wopereis, 2005). Searching and finding information otherwise can be time consuming and frustrating if the user is unfamiliar or unskilled with the program; these difficulties can persuade users to return to more traditional methods of data collection and distribution. Comparable to a construction environment, the healthcare industry is fast-paced. In a study conducted by Bertulis (2008), nurses' schedules were found to provide minimal time to access electronic resources. Nurses' low IT skill levels exacerbated this issue in many instances and lead them to either settle for lower quality electronic content or disregard the use of technology resources altogether. Based on the results of previous

industry studies, training was the most commonly recommended solution to alleviate concerns related to IT use and adoption.

General Information on Technology Training

A study by Kang (2010) recognized lack of training as a significant barrier to the adoption of IT in the capital projects industry. Particularly, initial training to conform to the use of tools was found to be especially beneficial by allowing users to experience the advantages of using IT. As a result, this establishes a positive outlook on adopting a new technology. Other industries have recognized similar trends, showing a positive correlation between IT skill level and training (Ahmed and Cooke, 2008; Egberongbe, 2011; Lazonder et al, 2000). More importantly, researchers have indicated that training has a positive influence on a user's acceptance of IT (Davis and Davis, 1990; Nelson and Cheney, 1987; Thong et al, 1994), and serves as an overall leveraging condition to the adoption and usage of IT (Salanova et al, 2000; Taylor and Todd, 1995; Thompson et al. 1991).

Literature Review Conclusions and Gaps in Research To-Date

Construction industry articles and reports have suggested that technology adoption is still low regarding onsite use (Kim, 2003; Komo News, 2013; Ward 2004), while others have indicated that IT is rapidly being adopted at the site level to counteract negative productivity trends (Khemlani, 2011; Sutton-Gee, 2012). Regardless, empirical evidence to support such claims is unavailable. The current state of site-level IT usage and skill level should be assessed to bridge this gap in knowledge.

To extend the use of technology in the industry, the impacts of technology on current site-level personnel's data collection activities and process-related tasks requires further scrutiny (Haas, 2000; Kiziltas et al, 2008). Independent and dependent factors remain highly influential in relation to IT adoption. As discussed, the hindrances of independent (i.e. human-related) factors remain highly speculative in many respects. Although dependent factors have continuously improved, the current effect they have on user's data collection and usage must be assessed (Chen and Kamara, 2011; O'Brien et al, 2011). Further industry experimental insight is necessary to better understand the independent and dependent factors surrounding technology adoption. Ultimately, additional empirical information surrounding this topic will allow for industry administrative staff to make corrective actions when contemplating the implementation of IT at the site-level.

Chapter Three: Research Methodology

The following section describes the method used to deliver the objectives established in Chapter One of this study. The steps taken and research questions developed that pertain to the objectives are provided first. The research data collections tools deployed and their purpose are then illustrated. Finally, the methods used to analyze the results of the data collection tools are explained.

Research Organization and Questions

The aim of this research is to provide substantial evidence related to the current state of IT use and potential sources of low IT adoption in construction at the site level. To this purpose, a survey, follow-up interview, and an IT training and evaluation exercise were deployed. These data collection tools obtained evidence for the established research objectives and associated questions which were disseminated into two main research steps. The objectives and questions were coordinated given the results of the literature review and observed gaps of knowledge that currently exist in the industry pertaining to IT adoption at the site level. Table 1 illustrates the general organization and research approach employed for this project.

Table 1. Research Strategy and Elected Research Methods

Research Step	Research Objective	Research Question	Research Method
Step 1	Investigate the current state of usage and skill-level of IT by site-level personnel in the construction industry compared	What is the current level of IT usage of site-level personnel for updating artefacts related to project-level activities?	Survey
		What is the current state of IT proficiency of site-level personnel for typical hardware and software related to data collection?	Survey
Step 2	Investigate the impact of IT when applied to site-level activities and identify potential barriers to the adoption of IT by site-level personnel in the construction industry compared to previous viewpoints.	Is there a correlation of use of IT according to skill?	Survey and IT Exercise
		What are the key construction environment and user-related factors that currently influence site-level personnel's onsite IT use for data collection, exchange, and re-use of information?	Interview and IT Exercise
		In which instances does the functionality of IT facilitate site-level personnel's daily tasks and	Interview and IT Exercise

For the first step, the objective and associated questions offer explicit evidence as to the industry's current state of IT usage and skill-level by onsite personnel. The intent of the first question is to identify how site-level personnel are currently producing or updating their construction process-related artefacts, which can be completed digitally or by traditional paper-based methods. These artefacts are based around general purpose tools characteristically employed for data handling. The objective of the second question is to gauge site-level personnel's present status of IT literacy of common technology

resources. The IT resources selected represent hardware and software commonly available for execution of process or task-specific activities in the industry.

The second step, objective and its associated questions reflect and provide empirical evidence to evaluate previously perceived barriers and current independent and dependent hindrances associated with IT adoption within the construction industry. The purpose of the first question is to determine the correlation of IT usage related to skill-level, and moreover, how improvements to skill can affect usage and influence site personnel's processes. The second question engages the independent factors correlated with IT usage. Individual feedback encompassing onsite integration and implementation of IT for daily activities and data handling was captured. The final question investigated the dependent factors related to IT adoption at the site level. Specifically, situations and conditions in which technology aids and obstructs site personnel's daily routines were directly enquired.

Survey Structure and Data Gathering

The survey is designed to provide information surrounding both of the research questions in the first step of the project and the first research question in the second step of the project. Responses were collected from onsite office and field personnel− specifically, project management and administration, superintendents, foreman, and field engineers.

The survey is divided into three sections and requests increasingly detailed information from participants. The intent of the first section is to capture demographical

and background information on the participants including their position, experience in the construction industry, the type of organization they work for, and the size of their company in terms of number of employees. The second section inquires about the participant's work activities, including how they distribute their time between the office and the field and their method of updating general activity-related artefacts which include forms and lists, sketches and drawings, spreadsheets and matrices, trend charts, schedules and lookaheads, meeting agendas, and plans and drawings; this segment offers evidence as to the current extent of site-level personnel that apply technology to perform their daily tasks. The final section requires respondents to provide a self-assessed skill-level in respect to generic IT tools including computers, tablet devices, communication devices, office software, internet resources, electronic spreadsheets, scheduling software and CAD tools; the frequency at which they typically use these tools on a given project was also noted. The final section had two purposes. The first, was to determine the current range of skill at the site level within construction related to generic technology tools and the second was to offer data that allowed a correlation to be drawn between the skill level of the users and their frequency of use of the tools.

Interview Structure and Data Gathering

The interview was deployed as a follow-up to the survey, specifically to provide further characterization to the field personnel's survey responses. The objective of the interview was to acquire a more well developed understanding of the impacts and barriers associated with IT implementation relative to site-level data collection and processes, but

more specifically, in relation to the field where currently the largest gap in knowledge exists related to IT adoption. The interview was devised to answer the second and third questions within the second step of the research. Responses were collected from field personnel including superintendents, foreman, and field engineers.

The preliminary set of interview questions pertains to the participants background information and the general responsibilities they have on their current project. The next set of questions requests feedback regarding the respondent's necessary creation and use of documents to complete their typical work tasks. The respondents were also asked to provide the influence technology has, if any, on the development and use of such documents. These questions provide insight on the independent, specifically user-specific and construction environment-related, factors that influence adoption and integration of IT at the site-level to execute daily activities. The last set of questions required respondents to provide occasions in which technology has facilitated or delayed their processes. Additionally, respondents were asked to offer their opinion on general improvements that could be made to their daily activities through adoption or removal of IT by their company. The intent of this set of questions was to offer evidence on the dependent factors, specifically the perceived value and barriers of using hardware and software applications, related to IT adoption at the site level.

IT Training and Evaluation Exercise Structure and Data Gathering

The IT training and evaluation exercise was extracted from a separate stream of research that was used to analyze a type of software that allowed users to electronically

mark-up and manipulate drawing sets onsite when used in conjunction with a mobile device. The information gathered from the training exercise was incorporated into the context of this paper as supplemental content to the three questions in the second step of this research study. Particularly, the study addresses the first question regarding the correlation between frequency of IT use and skill level. A combination of the survey and IT exercise allows for a full evaluation of this concept. The survey provides a snapshot of the effect that current skill sets within the construction industry have on frequency of technology usage, while the training and evaluation exercise provides insight on how an increase in skill level factors into frequency of use and acceptance of IT at the site level.

The exercise consisted of an electronic drawing set, training scenarios, and a software evaluation sheet. The electronic drawing set was a generic set of plans that worked in conjunction with the training scenarios. The training scenarios were structured to mimic typical task-related objectives or activities required for communicating changes and information associated with marking up drawing sets (Bluebeam, 2013; Brandt, 2013; Khemlani, 2011; Shira, 2013). The tasks-related scenarios simulated within the training sessions included, (1) making design changes, (2) providing RFI clarification, (3) providing clarity to comments with the use of pictures, (4) providing as-built sketches and notes, (5) sifting through design information, and (6) sifting through old drawing mark-ups. Each scenario is set-up to provide context and background information as to the purpose of the task and then presents a series of required steps to complete the assigned task utilizing the software's available functions. After the scenarios were completed in an onsite construction environment, users were asked to submit feedback on

the software by means of an evaluation sheet. The evaluation sheet was divided into four categories and subcategories that outline the potential benefits of using mobile technology in conjunction with electronic drawing set software – including, visibility of the drawing set, mobility of the drawing set, ability to communicate changes and information, and overall effectiveness of the IT functionality to complete the objectives set forth in the training scenarios. Users were asked to gauge their experience with the software by comparing it to paper-based methods on a Likert Scale of 1 to 6; where 1 indicates the software was significantly less satisfactory than paper-based methods and 6 indicates the software was significant more satisfactory than paper-based methods. The last page of the evaluation sheet provided follow-up questions that had users indicate their overall approval of the software including, their acceptance, perceived complications of the software, and how they felt it would impact their daily activity performance. The IT training and evaluation exercise offers insight into how an introduction and increase in skill level of a technology can affect usage and acceptance of IT at the site level. This exercise also offers information on how introducing an IT application through training may impact site-level personnel's methods of data handling and, by association, the benefits or hindrances of technology to their daily tasks.

Methodology for Analysis of Results

Different approaches were taken in analyzing the results accumulated from the data collection tools described within the three previous methodology sections. The survey results were compiled in a spreadsheet and translated to a bar chart format which

allowed for further analysis. The responses to the follow-up interview and IT training and evaluation exercise were reviewed, filtered, and sorted into general and specific findings in accordance to their relevance to the research questions.

For the survey results, in varying instances respondents were either grouped as a whole or categorized into two general job classifications. The classifying of respondents in some cases allowed for a more thorough analysis in reference to specific levels of IT adoption and skill based on onsite job functions. In instances where respondents were categorized, superintendents, foremen, and field engineers were classified as field personnel. The remaining respondents were project managers and were classified as office personnel. A determination of job classification was made given the participants' overall responses to the survey regarding how they typical distribute their time in a general work setting. A summary of the responses are presented in Table 2 and Table 3, below. At large, field personnel stated they spend approximately 40% or more of their time in the field supervising activities. On the other hand, office personnel were found to spend a minimal amount of time in the field, 20% or less, and then distributed their remaining time amongst meeting project stakeholders, working independently at the office, and performing "other" activities.

Table 2. Construction Field Personnel's Self-Estimate of Approximate Time Spent in Typical Site Settings

Time Spent (%)	Supervising field activities?	Meeting project stakeholders?	Working independently at the office?	Other
0-5%	0	4	2	5
5-10%	2	12	5	15
10-20%	4	7	7	5
20-30%	2	2	6	1
30-40%	0	3	3	1
40-50%	3	0	2	1
50-60%	3	0	1	0
60-70%	3	0	2	0
70-80%	7	0	0	0
80-90%	2	0	0	0
90-100%	2	0	0	0

Table 3. Construction Office Personnel's Self-Estimate of Approximate Time Spent in Typical Site Settings

Time Spent (%)	Supervising field activities?	Meeting project stakeholders?	Working independently at the office?	Other
0-5%	1	0	0	3
5-10%	19	5	0	17
10-20%	7	9	4	4
20-30%	1	4	4	3
30-40%	0	5	6	1
40-50%	0	3	2	0
50-60%	1	3	5	1
60-70%	1	1	5	0
70-80%	0	0	1	0
80-90%	0	0	2	0
90-100%	0	0	1	1

It should be noted, respondents were asked to divide their time accordingly amongst the four categories presented, such that it added up to 100% of their time. In most instances, the respondents followed this procedure. However, because the above tables are a compilation of responses, a simple review of these tables will not reveal this qualification. Furthermore, given that percentage ranges were offered, results may not add up to precisely 100% of their time, depending on the respondent's individual interpretation of each range. Individual responses have been included in Appendix A.

As mentioned, the open-ended responses to the interview and IT training and evaluation exercise are presented sequentially in accordance with the provided research questions. Participants and their responses were sorted and consolidated into "general findings" categories based on the author's own discretion of observed data trends. For example, in relation to the third question in step two of the research (the hindrances associated with dependent factors and IT adoption), if an abundant amount respondents indicated that they experienced delays when attempting to transfer data from one technology source to another, the author may indicate a strong presence of technology interoperability issues still exists and impedes onsite productivity within the industry. Following, individual responses are highlighted, to further support and clarify the "general findings" categories presented.

Chapter Four: Results

This section offers an overview of the results of the survey, follow-up interviews, and IT training and evaluation study. Introduction and demographical information related to each data collection tool are presented first. Following are the results of each tool.

Respondents' Demographical Information

The general results from the survey are highlighted in the following two sections; consisting of a total of 58 respondents, including 28 field personnel and 30 office personnel. The majority of the respondent are employed by large North American companies with more than 1000 employees. The survey participants offered a well distributed array of construction industry knowledge ranging from 1 to 40 years of professional experience. Appendix A contains more comprehensive information regarding specific demographical information of the respondents and detailed results of the survey.

The next section distinguishes the outcomes of the follow-up interview responses. The results offer the general findings obtained from the interviews as they pertain to the research questions. Specific findings and responses relevant to the general results will also be presented to provide further context and clarity. A total of 19 responses were collected from field personnel. The participants included 2 field engineers, 13 superintendents, and 4 foreman with experience ranging from 2 to 36 years. The average experience of participants was 22.2 years. One respondent was employed by a

municipality that focused on maintaining existing infrastructure, and the remaining respondents either worked for one general contractor in commercial construction or two EPC firms in the industrial sector. Appendix B presents more detailed information regarding respondents background experience.

The final segment discusses the results of the IT training and evaluation exercise. Descriptive all encompassing findings are offered based on the outcomes of the exercise. A total of 3 participants were incorporated in the study including a construction manager with 25 years experience, a project engineer with 8 years experience, and a field engineer with 5 years experience. The exercise was performed on a single commercial construction site based out of San Antonio, Texas. Appendix C offers more detailed information on participants and their general experience.

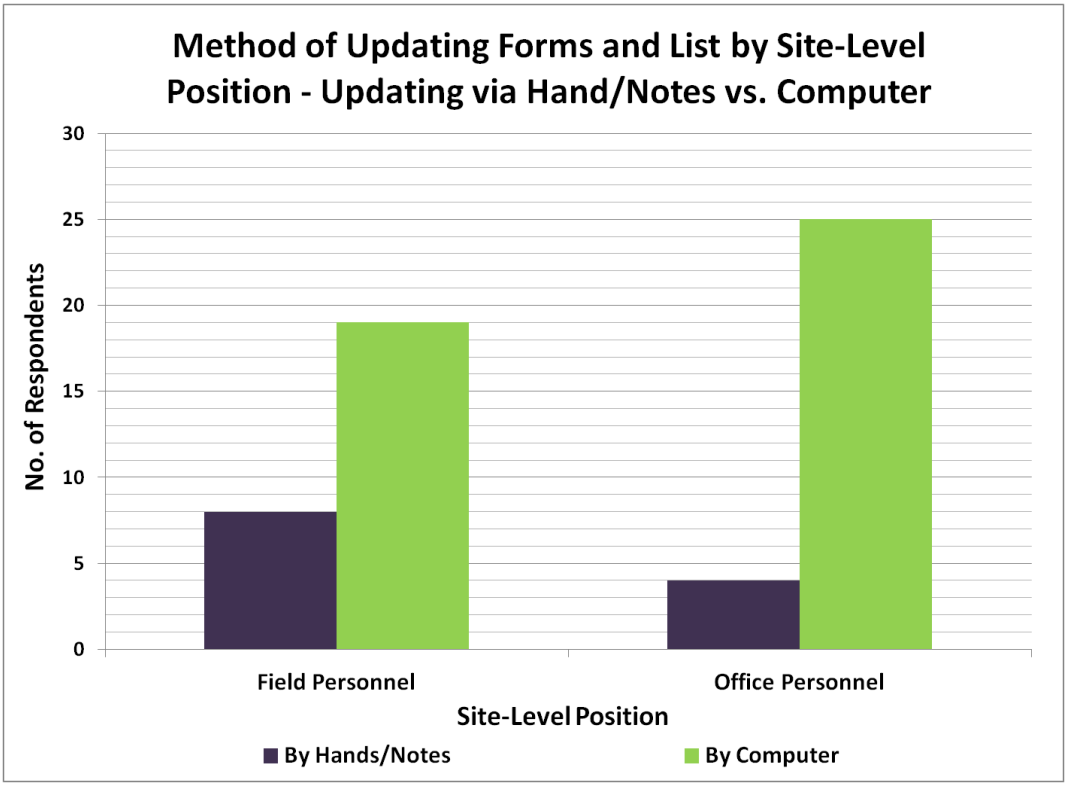
Survey Data Section 2: Method of Updating Artefacts Related to Site-Level Activities

In the survey, respondents specified their current method of updating artefacts typically related to construction daily processes. To maintain an genuine level of understanding, participants were presented with an artefact and then asked to simply indicate whether they typically use a computer or hand notes for updating. For additional insight, the results were compiled and presented as bar charts (See Figure 1). Figure 1 below is an example of these bar charts; the remaining charts are included in Appendix A.

For this portion of the study, respondents were separated into two categories, field personnel and office personnel (See Chapter 4: Methodology). Depending on the artefact

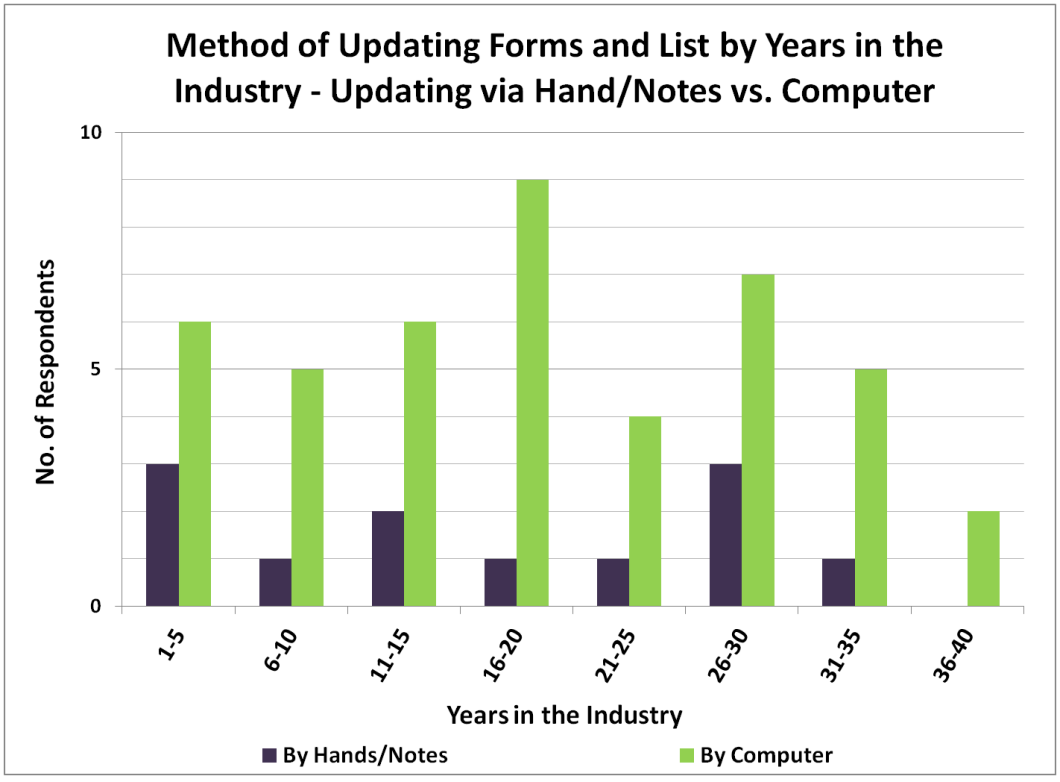
provided, between 70% and 90% of field personnel were found to update the majority of their artefacts by computer, including forms and lists, spreadsheets and matrices, trend charts, schedules and look-aheads, and meeting agendas. Updating of sketches, drawings, plans and specifications sets were found to be the exception; where approximately 46% to 54% of field personnel make updates to these artefacts by hand. Overall, office personnel displayed a slightly stronger presence of IT usage in all artefact categories. Again, depending on the artefact provided, between 83% to 100% of office personnel, indicated that they update the majority of their artefacts by computer. Similar to field personnel, the updating of sketches, drawings, plans and specification sets presented outliers. In general, 64% to 68% of office personnel update these artefacts by hand.

Figure 1. Method of Updating Artefacts by Site-Level Personnel Bar Chart Example



Next, a preliminary investigation was performed to assess the validity of previous viewpoints; in this instance, that seasoned employees are more reluctant to accept IT into their daily tasks. To complete the investigation the entire population of responses for updating activity-related artefacts was aggregated with the participant's responses to the questions regarding experience in the industry. This exercise allowed for a review of potential trends regarding IT usage in relation to age and latter industry generations resistance to change (See Figure 2). Figure 2 below presents an example of this collection; the remaining figures are included in Appendix A.

Figure 2. Method of Updating Artefacts by Years in the Industry Bar Chart Example



This process yielded no distinct results or offered any trends. In essence, no direct correlation between IT adoption in accordance to age was observed. In general, a stronger correlation was observed between usage of IT according to time spent in the construction office or field. As a result, a determination was made to perform a more in-depth analysis of potential user-related hindrances associated with adoption of IT in Step 2 of the research.

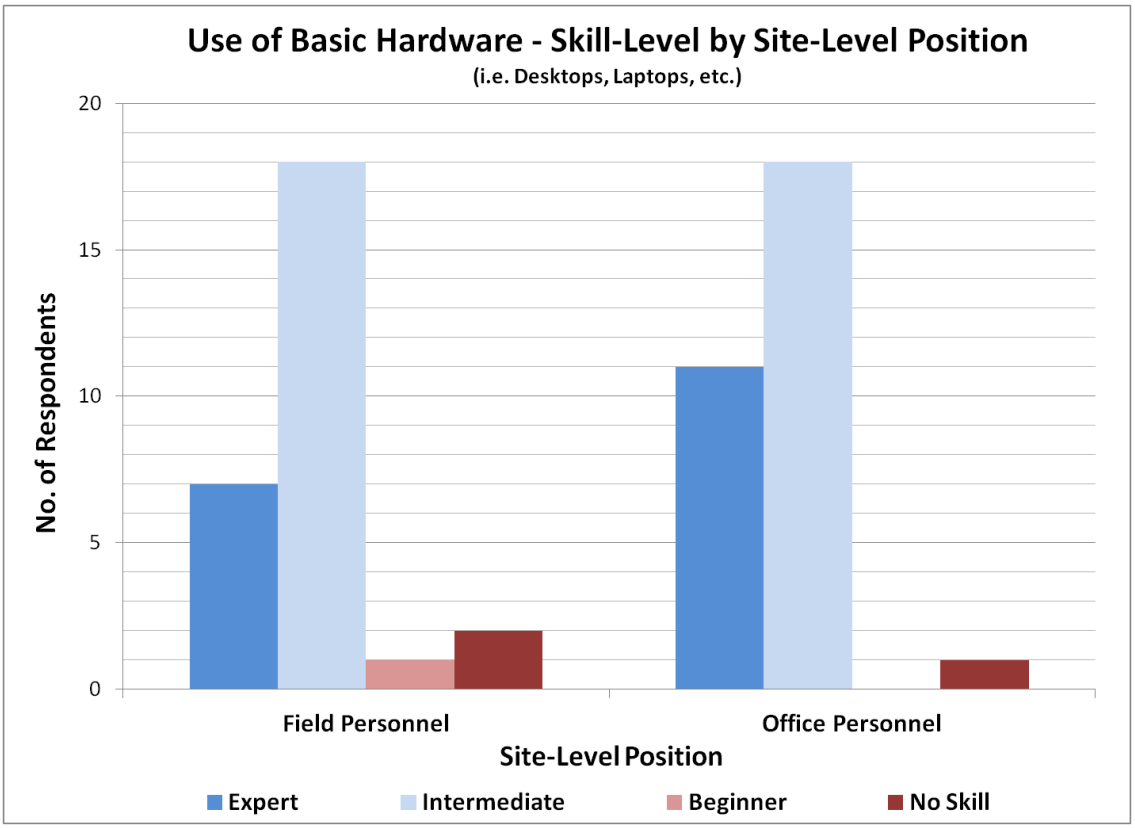
Survey Data Section 3: Construction Related Electronic Resources - Skill Level and Frequency of Use

In the survey, respondents indicated their own self-assessed skill-level in relation to the use of generally available IT tools in the industry. Participants were presented with an IT tool, asked to indicate their proficiency with the tool, and then specify how often they use these tools on a project. For further analysis, the results were compiled and presented as bar charts. First, in correlation with the second question in Step 1 of the research, the results were strictly displayed in relation to skill-level (See Figure 3). Following, the respondent's skill-level was cross-referenced with their answers on the frequency at which they utilize the IT tools to provide context to the first question in Step 2 of the research (See Figure 4).

The results corresponding to skill-level were divided by the field personnel and office personnel job categories (See Chapter 4: Methodology). For the majority of IT tools presented, including basic hardware devices, communication devices, internet resources, electronic spreadsheets, and time/task management tools, approximately 86% to 93% of field personnel specified that they were intermediate or expert users. The

outliers included electronic office documents, touch screen devices, scheduling software, 3D scheduling software, and drafting software, where respectively 64%, 68%, 50%, 33% and 32% of field personnel indicated themselves as intermediate or expert users. Office personnel also claimed to be adequately skilled in the majority of the IT tools presented. To be specific, approximately 90-100% of office personnel stated that they were intermediate or expert users when it came to utilizing basic hardware, communication devices, electronic office documents, internet resources, electronic spreadsheets, and time/task management tools. Parallel to field personnel, with the exception electronic office documents, office personnel were found to be less proficient users of touch screen devices, scheduling software, 3D scheduling software, and drafting software. Respectively, for these tools, 77%, 53%, 20% and 30% of office personnel indicated themselves as intermediate or expert users.

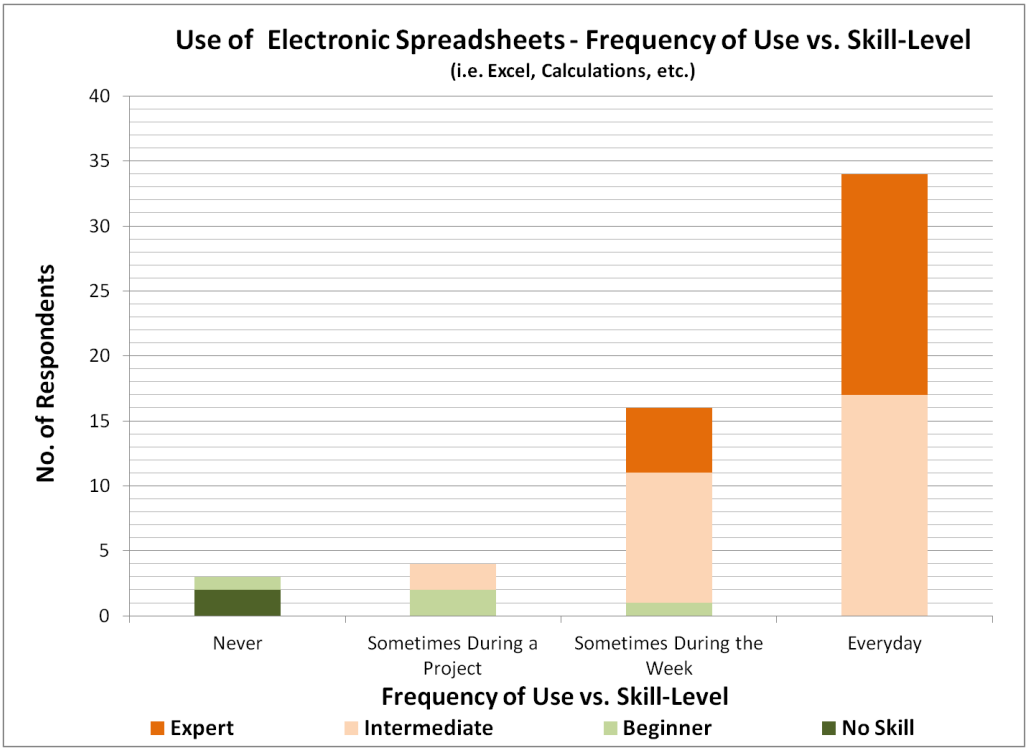
Figure 3. Use of General Industry Available IT - Skill-Level by Site-Level Position Example



Based on the second set of bar charts developed (See Figure 4), a strong correlation between skill-level and the frequency at which field personnel utilize IT tools could be observed. The majority of the graphs revealed that site-level intermediate and expert technology-users tend to employ IT tools on a more frequent basis, either daily or several times during the week. On the other hand, site-level personnel with no skill or a beginner skill set, in most cases appeared to rarely or never use the presented IT tools during a project. In a few instances, users with beginner skill sets claimed to use some of the IT tools on a weekly basis or daily. Intermediate users were also more flexible in a few instances, claiming to use certain IT tools only sometimes during a project or in one

instance, never. However, these were found to be exceptions to the overall trends presented.

Figure 4. Use of General Industry Available IT - Frequency of Use vs. Skill-Level Example



Interview Results

The interview results help identify independent and dependent factors that affect the adoption of IT by field personnel. Interview responses pertaining to the independent factors are stated first; specific instances are provided in which user and construction industry aspects influence field personnel's adoption of technology to supplement their daily tasks. Following, the results corresponding to dependent factors are engaged;

interview responses highlighting facilitations and hindrances associated with IT functionality in specific situations are illustrated.

Independent Factors

Based on field personnel's responses as a whole, onsite tasks commonly require information exchanges and the development of documents that incorporate requests-for-information (RFI's), schedule tracking and updates, site and safety data, daily report and inspection records, quantity take-offs, quality control data, and updated plans and specifications. To complete these tasks and develop the necessary supportive artefacts, respondents used paper-based methods, electronic documents and devices, or a combination of both. In accordance with the extent of technology used, participants were characteristically affiliated with one of the following categories,

- **Category One - Strict use of paper-based methods in the field and office:** All documentation for onsite data collection and exchanges is developed and transferred by paper-based methods. No electronic documents or devices are utilized in the field or onsite office.
- **Category Two - Use of paper-based methods in the field, but some use of IT in the onsite office:** No electronic documents or devices are used in the field; all in-field data is collected by paper-based methods. On occasion, a transfer of in-field collected data to an electronic medium occurs as a secondary step in the onsite office.
- **Category Three - Minor use of IT in the field, but heavy use of IT in the onsite office:** Electronic devices, such as smart phones, are used in the field to

execute simple communication-related exchanges and review electronic documentation developed earlier at the site office. All other documentation, created by paper-based methods, utilized for task-related data collection and exchanges is transferred to an electronic medium at the onsite office.

- **Category Four - Combined use of paper-based methods and IT to support in-field and office activities:** A proportionate combination of paper-based methods and IT are used to collect and exchange information related to onsite tasks; in this instance, some tasks are semi-automated in the field with the use of IT and other tasks remain paper-based. The automated tasks are typically supplemented by mobile devices to support data handling in the field. All remaining paper-based documentation utilized for task completion is typically transferred to an electronic medium at the onsite office.

Respondents that fell within the first two categories shared similar characteristics and lacked adoption of IT in the field; a few of them utilized hardware and software at the site office. These respondents mostly utilize paper-based documentation to exchange and re-use information; on occasion the use of e-mail and phones was the only stated exception to this rule. This often required them to carry and handle hardcopies of documents in the field and at the site office; as a result, trips back and forth to and from the site office were typically necessary to obtain and exchange up-to-date information and perform required daily tasks. Although the basis for this lack of IT use varied, by and large the limited use of IT could be linked to user- and industry- related hindrances. Several respondents, predominantly individuals in category one, indicated that they lack

the necessary skills to effectively use IT tools in the field or office. A number of these personnel were required to rely on others to assist them in the electronic transfer of collected onsite data or stated that re-entering the data into an electronic format was very time-consuming. For example, one superintendent admitted to limiting his use of computers due to the fact that he had a difficult time locating and organizing electronic files. It should be noted that the same superintendent and similar respondents often acknowledged the benefits of IT, and that training would likely increase their effective use of the technology available to them. Several other respondents indicated that lack of IT use was due to the fact that it was unavailable to them through company means. One field engineer in particular stated he was proficient in the use of IT, but was not provided mobile technology to execute field tasks. In fact, information collected by hand in the field by the field engineer was only required to be submitted electronically on a monthly basis to execute pay requisitions. In rare contrary cases, respondents despite having the use of IT available to them, preferred to update documents by hand or electronically at the office due to dynamic construction environment issues. For example, a superintendent specified he preferred to complete daily reports at the site office so as not be distracted or persuaded by the high-energy in construction field. Ultimately, the respondent recognized daily reports as a legal document and was concerned with making a mistake or including notes that might be out of context due to controversy on site. Other respondents stated that the direct use of IT in the field or onsite was prohibited due to client restrictions. Restrictions were set in place to maintain confidentiality of ongoing

site work and the technology involved on the project. In most cases, this was typical of industrial projects.

Field personnel cataloged within category three and four showed similar qualities and often adopted technology to supplement their tasks. Most of these field personnel used technology when it was made available to them, and returned to paper-based methods in all other instances when it was unavailable. The majority of their information exchanges were performed with the use of IT and their reuse of information derived from accessing electronic resources with the help of mobile devices in the field or computers in the site office. Several respondents within these categories indicated that they can use and manipulate general purpose software (i.e. word processors or electronic spreadsheets) to develop their own documentation; they subsequently access these documents electronically in the field for onsite decision making or for reference during meetings with project stakeholders. In these cases the use of IT was often self-employed. For instance, one superintendent specified that he would often develop his own schedule inclusive PDF's and spreadsheets in the office and access them with the use of his phone in the field. The basis for moving the schedules to an electronic medium was to facilitate communication with stakeholders.

At times, adoption of IT by field personnel within the last two categories was a requirement; their company's practices made the use of IT essential to complete their daily tasks. Respondents indicated these requirements were often met with standardized company-issued electronic documentation or software platforms. Depending on the availability of mobile technology available to them, respondents executed these IT based

processes in the field electronically or by hand, which required further organization and transfer to an electronic medium later at the site office. In one case, a few superintendents from the same company were obligated to collect safety information through the use of a company-developed program. The superintendents were offered tablets or smart phones to collect the information in the field. Safety data entered into the program was automatically compiled and presented graphically. The superintendents, with the use of mobile technology, were then able access that data for future use during meetings and safety talks. Superintendents for this company welcomed the use of the software and appeared to have a well-developed understanding of the associated benefits. In fact, many of the same superintendents were requesting the use of additional software to further automate their infield practices. A couple foremen, from a different company, were also required to use technology to supplement their daily practices. These respondents indicated that the use of tablets on site was prohibited, but an electronic document management system back at the site office was available to complete their daily tasks. The foremen would be required to take hand notes on site and later transfer them into to the program back at the site office. The information could later be pulled back for their use by logging back into the program at the office or by printing hardcopies of the information and bringing them into the field. Although they were aware of the benefits of the software and in many cases it facilitated their processes, they were also often frustrated. Part of the frustration was the level of effort it took the foremen to enter the data up front; this was often time-consuming due to a lack of IT skills on the

foreman's part and exacerbated by the abundant amount of information that was required. To alleviate this issue one foreman suggested the company implement formal training.

Dependent Factors

Field personnel's responses related to the dependent factors of IT, necessitated IT functionality to be divided into two main categories,

- **Category One - Physical Characteristics:** The first category encompasses the affects the physical characteristics of IT have on field personnel's daily tasks. Examples include, but are not limited to, hardware mobility, the ability to view the electronic display, and the connectivity of the wireless link.
- **Category Two - Software Capabilities:** The second category covers the impacts software's capabilities have on field personnel's daily tasks. Examples include, but are not limited to, the ability to navigate the software's interface and locate information, the ability to collect and populate proper task-related data, and the capacity to exchange documentation efficiently.

IT physical characteristics that facilitate and hinder field personnel's daily tasks are highlighted first. Subsequently, the facilitating and hindering features of IT linked with software's capabilities are provided.

In general, only one common facilitating attribute that corresponds with the physical features of IT was specified by participants; the mobility of current hardware, and by association, the ability to access information instantaneously in the field or office. Typically, in these instances, accessed artefacts pertained to plan and drawing sets, RFI's, schedules, material/procurement information, and trend charts. For example, one

superintendent stated that the ability to access RFI's in the field with the use of his phone, in real-time, allowed him to relay information to subcontractors in a more efficient manner, allowing them initiate work dependent on RFI's earlier. Smart phones in particular, were praised for their versatility and compact nature in relation to mobility.

Conversely, several physical features of IT were found to be problematic. Some field personnel stated that large mobile devices were too bulky to constantly carry them around site. Other respondents found the screens on smart phones too small to review documents or enter information, outside of texting and e-mail. In one case, a superintendent preferred devices with a larger screen because he often had difficulty entering data into his company-developed safety program with his smart phone. Several respondents expressed concerns on the complete reliance of IT as a document management system and storage device. To further explain, these participants stated that without a paper-based system in place, if technology is abruptly made unavailable to them (i.e. running slow, the available wireless connection is temporarily unresponsive for an extended period of time, or the system has a major malfunction), then the ability to access necessary task-related information may be completely lost. For instance, on one site in particular, superintendents complained about their current document management software due to its slow response time, which often led to reduced task efficiency. From a different standpoint, other respondents mentioned that there is too heavy of a reliance on IT as a physical means of communication; several participants stated that, at times, there is the need to have face-to-face conversations. For example, one superintendent, who was alluding to discussing onsite safety with craftsmen, acknowledged that there is a

necessity to examine workers mental and physical fitness during a conversation, which cannot be achieved with the use of technology. Another superintendent within the same frame of reference, stated the presence of multiple IT devices onsite causes delays due to their distracting nature.

Respondent's were able to identify a number of instances in which the capabilities of software platforms offered value to their daily tasks. The overall versatility and simplicity of basic software interfaces was found to aid field personnel frequently throughout their daily routines. E-mail, photos, word processors and electronic spreadsheets accessible through a mobile device allowed some respondents to record notes or create artefacts in the field, which they could then reuse for their own reference back at the office to complete task-related documentation (e.g. quality control report). For instance, one superintendent mentioned that he habitually uses e-mail on his phone to take notes in the field, which he later uses at the office to update schedules and punch lists. Standardized company issued software (i.e. software that has been implemented and some instances developed by the company to support construction site tasks) was praised by respondents for its ability to keep information consistent and provide various stakeholders access to the information; respondents, in many instances, signified that their ability to disperse consistent and organized information to the entire project team, almost instantaneously, was the primary benefit related to the use of this type of software. Other respondents indicated the ability to perform searches with standardized company issued software for the purpose of reusing information was also valuable; particularly when they were looking to use information from previous projects as a reference to

current projects and information from current projects during meetings with stakeholders. For example, one field engineer discussed using his company's standardized software to reference procurement times on previous projects to forecast procurement durations on his current project. Software that can be utilized as a visual tool (e.g. 2D/3D CAD) was indicated by a few respondents from various companies as a valuable asset to their daily tasks. One field engineer alluded to utilizing building information models (BIM) to facilitate communications with subcontractors, ultimately allowing him to provide clarity to the conversation through visual context. Another example included a superintendent, who discussed the benefits of using BIM as a tool to simulate daily work prior to performing it in the field, allowing his craftworkers to efficiently plan their work ahead of time and avoid mistakes.

Software capabilities in some circumstances were more of a burden to respondent's daily tasks. Some field personnel indicated that software became problematic when the overall interface and utility was too complicated to learn in a timely fashion. In these instances, respondents stated it was sometimes difficult to get new-hire users trained and caught up on the technology. In parallel instances, respondents sometimes found that although the their level of proficiency with the software was adequate, subcontractor's or other stakeholders on a new project were not as proficient with the software; this sometimes made communication of onsite information between project entities difficult. One example of this was highlighted by a superintendent, who was required to transfer his scheduling information to an electronic spreadsheet so his subcontractors could examine and interpret it. The superintendent found the transferring

of the schedule data over to a different electronic medium repetitive and time-consuming. Some participants indicated another software capability that they often had difficulty with was the search and organization functions of company-issued programs, contradicting respondents referenced in the previous paragraph. In that regard, these respondents specified that some software search functions are simply not "user-friendly," making it time-consuming to navigate the program and locate information necessary to complete a task. One project superintendent stated that he reverts back to paper-based methods when he has these types of issues with software. When these issues arise, the superintendent found that paper-based methods can be quicker to access and communicate necessary information to craftsmen. A different superintendent indicated, in these instances instead of reverting back to paper-based methods, he sometimes regresses back to more basic hardware (i.e. word processor) to keep information organized so that he can communicate with other project entities in a more timely manner. Another identified hindrance of company-issued programs was that they seemed to have a tendency to contain a slightly more rigid interface, such as pull-down menus, requiring very specific data entries; one superintendent stated this made data collection inherently time-consuming and inflexible. The last major software capability issue identified was related to interoperability. This issue, in some cases, caused some respondents to experience double handing of data, in that they were required to re-enter data into several programs so all project stakeholders could access the project-related information. For example, one superintendent stated that his company's financial department software was unable to communicate with the electronic spreadsheet software they were using on the project to track cash flow

information. As such, he was required to enter financial data into both software mediums, resulting in lost time.

With the exception of the one superintendent who reverted back to paper-based methods due technological difficulties, it should be noted that overall dependent factors that hindered respondents daily tasks did not appear to deter users from using technology all together. Several field personnel even indicated that in instances when technology was a significant enough burden to personnel's daily tasks, either they or the company would remove the technology from their processes and replace the old technology with a new one.

IT Training and Evaluation Study Results

To reiterate, the technology tested in this study was a type of software that allowed users to electronically mark-up and manipulate drawing sets onsite when used in conjunction with a mobile device. The IT training and evaluation study results provide an example of how the implementation of a new technology into site-level personnel's existing processes can affect their work. The results also show how training and an increase in proficiency of an IT tool can influence it's acceptance and adoption. First, a brief synopsis of the results related to the evaluation of the IT tool compared to paper-based methods will be provided. Then, the respondents answers to the follow-up questions concerning their acceptance, perceived complications of the software, and how they felt it would impact their daily activity performance are summarized.

By and large, the three respondents established that the technology's capabilities were more satisfactory than their previous paper-based methods associated with marking up drawing and plan sets. To be more specific, based on the respondent's answers to the Likert numerical evaluation, in all instances related to plan set visibility, overall mobility, information exchange and communication, and task-specific functionality, the software was found to be a superior method. Respondent's also indicated that they recognize the four aforementioned IT functionalities highly important to the successful completion of their daily tasks. Some commentary provided within this segment of the IT exercise offers further context. The construction manager stated that having access to electronic drawing files in the field helps ensure that you are always working with the most current version of the drawings. The field engineer stated that overall he found the functionality of the software to provide a greater level of onsite efficiency than paper-based methods.

Following the training procedures, all three respondents indicated that they would recommend the implementation of the IT tool full-time. This signifies all respondents voluntarily accepted and would be willing to adopt the IT into their existing processes. All respondents also indicated they would perform and share drawing revisions and updates at a higher frequency with the availability of the IT tool; by association the users would be required to utilize the technology at an equivalent regularity. Finally, the respondents determined that the efficiency of the software would save time related to marking up drawing sets, allowing them to allot more time to other daily activities. Two minor complications related to the implementation of the software were identified. One complication was the time-loss and inefficiency that is inherently associated with the

training process. The second complication discusses the learning curve of user's; the construction manager indicated there would be a time-period in which users would need to determine how to most efficiently make use of the software tools available to them for specific tasks. No further complications were mentioned.

Chapter Five: Discussion

The results of the data collection tools highlighted in the previous section of this study offer evidence as to the current state of construction site-level IT use and proficiency, and hindrances associated with adoption of IT in the industry. This section discusses those results in accordance with the research questions presented in Table 1, which were derived from observed gaps of research in the industry related to IT use at the site-level.

IT Usage of Site-Level Personnel

The first question in step one of the research inquired about the current level of IT usage of site-level personnel in the industry to produce and update project artefacts. The associated results of the survey show a significant level of IT usage and adoption by site-level personnel. To be more precise, the results stated that 70% to 90% of field personnel and 83% to 100% of onsite office personnel designated the use of computers to update the majority of their artefacts, with sketches, drawings, plans and specifications being the only exceptions. The quantity of field personnel who indicated that they develop artefacts digitally is much higher than anticipated. Based on the analysis of "computer usage" against various "years of experience in the industry," technology appears to be equally used by all site-level personnel, inexperienced and seasoned alike. It was observed that the integration of technology at the site-level during the construction execution phase is much more advanced than previous perceptions suggest. No distinctive correlation was

observed regarding resistance to accept IT based on construction personnel's age, as previously advocated by industry literature.

IT Proficiency of Site-Level Personnel

The second question in step one of the research inquired about the current state of IT proficiency of site-level personnel in the industry. The associated survey responses indicate that a rather high level of working knowledge related to construction technology currently exists in the industry at the site level. Specifically, the results revealed that for more basic tools 86% to 93% of field personnel and 90% to 100% of onsite office personnel are intermediate or expert users. A slightly smaller group, but still the majority of respondents of field personnel and onsite office personnel, indicated being proficient users of more advanced technology such as touch screen devices. For the most advanced IT tools proposed, a less significant portion of participants, approximately half of the respondents or less, indicated they were proficient users. In most cases, the use of basic and slightly more advanced IT should be adequate in assisting users with their data collection processes. Although there is room for improvement with the use of advanced tools onsite, the results of the survey regarding the current state of site level technology proficiency suggests that there is a strong basis for technology adoption and use on construction project sites. Moreover, IT literacy of site level personnel is presently much greater than previous literature suggests.

Impact of IT Proficiency on Technology Usage by Site-Level Personnel

The first question in step two of the research inquires about the potential affiliation between the user's IT aptitude and the frequency at which they use technology. This question is analyzed based on the results of the survey and IT training and evaluation exercise. The graphics developed, integrating user's responses directed toward their current skill level and frequency at which they use certain IT tools during a project, show a strong correlation exists between user's IT proficiency and how often they utilize technology tools. Construction site-level IT users that access certain technology tools on a regular basis to supplement their daily tasks were genuinely found to be more skilled with those definitive tools. Conversely, in instances in which construction site-level IT users appeared to avoid the use of a certain tool, their proficiency with that definitive tool was significantly lower; this was observed particularly with more advanced technologies such as advanced scheduling or 2D/3D drafting software. The training and evaluation exercise results supplement the survey findings. The three respondents, who all had an opportunity to develop their skills with the IT tool, indicated that they would recommend the use of the technology on a full-time basis, integrating it into their existing practices or methods for collecting and exchanging onsite information. The group of the participants as a whole, also indicated that their frequency of developing related documents would increase with the use of the IT tool. Based on the results, a strong correlation can be observed between how an increase in skill can weigh on user's overall acceptance of a tool and the frequency at which they choose to use the tool. In conjunction, the results suggest, a definitive relationship exists between the frequency at which site-level

personnel choose to utilize a technology and their proficiency with that technology, as previously observed in other industries outside of construction; rather, the more efficient and skilled a construction site-level user is with a tool, the more likely they are to accept and employ that tool to execute their tasks. The results of the IT training and evaluation study also suggests that onsite training may be a facilitating factor in the acceptance and increased use of IT by site-level personnel.

Influence of Independent Factors on IT Adoption

The second question in step two of the research inquires about independent factors that influence the adoption of IT at the site-level. The interview and IT exercise results offer empirical evidence that allows for an examination of this question. At large, the results suggest that independent factors (i.e. users and the construction environment) have a very significant influence on site-level adoption; users proficiency with IT and industry business-related limitations appear to carry the strongest weight.

Regarding users, skill-level was observed as the most influential factor to adoption. Lack of skill was found to be especially hindering for many respondents, typically respondents in category one and two of the results (i.e. infrequent users of technology). Site-level personnel would limit their use of IT, particularly in instances when their restricted IT capabilities actually caused them to be less efficient with technology than with paper-based documentation. Conversely, adequately skilled technology users, especially users in categories three and four (i.e. frequency technology users), would intentionally implement technology to supplement their daily tasks, even

when it was not necessarily required of them; an example of this can be seen with the superintendent who would carry and reference PDF's of his schedules and spreadsheets in the field with the use of his smart phone. This hindrance should not be mistaken with user's unwillingness to implement IT. In several instances, users with inadequate technology skills were requesting their companies offer further technology training. The dynamic nature of this observable fact was also witnessed in the IT training and evaluation study; once the user's were introduced to the benefits of the technology and their associated level of skill was adequate enough, they were accepting of the technology tool presented to them and willing to implement it on a full-time basis.

Linked to the industry environment, construction business-related limitations were observed to be the most prominent barriers associated to the adoption of IT at the site-level; specifically, project restrictions and company culture emerged as the most hindering factors. Projects and companies that did not provide the opportunity to capitalize on technology use, particularly in the field, severely limited the potential for site-level personnel to adopt IT. This was witnessed explicitly with the various foremen and superintendents whose use of IT in the field was limited on industrial project sites, and the field engineer whose company did not provide him the means to utilize technology in the field. In contrast, field personnel highlighted in categories three and four of the results (i.e. frequent users of technology) were provided the means to utilize IT in the field. In several instances, respondents were required to use technology, given their company's technology-based processes and company-issued software; this could be observed particularly with the superintendents who were required to use company-issued

safety software in the field. It was observed that when IT is forced onto site-level personnel, it is essential to ensure that their proficiency with the provided technology is adequate. Training was suggested as a viable solution by several respondents, when they found their skill-levels to be insufficient. If their proficiency is not improved upon, then technology may be more of a hindrance to their daily routine than a benefit.

Influence of Dependent Factors on IT Adoption

The third question in step two of the research inquires about the dependent factors that influence adoption of IT at the site-level. The interview and IT exercise results offer empirical evidence that allows for an examination of this question. The results of the interview suggest that dependent factors, by and large, moderately weigh on the acceptance and adoption of IT; respondents indicated that in situations when IT was hindering their daily tasks, either they or their company would eradicate the technology from their practices and replace it with a new one. Therefore, while acceptance of technologies may be temporarily impeded by problematic features of some IT, the adoption of IT altogether at the construction site-level does not necessarily directly rely on technology to function perfectly.

When discussing the dependent factors of IT usage during the interview, the physical characteristics and software capabilities of technology were found to carry the most heavy weight related to acceptance of IT by field personnel. Technology features that are imperative to the approval and adoption of technology, include the visibility, mobility, information exchange, and functional task-specific capabilities of technology,

which are all considered highly important by users, as observed in the IT training and evaluation exercise.

From a physical characteristics perspective, IT appeared to have a significant range of facilitating and hindering features. The physical feature found to best supplement and facilitate field personnel's tasks was the overall mobility of devices and accessibility to information current technologies provide at the site-level. The barriers or concerns related to the adoption of IT in the field covered a wide spectrum of thought processes. The least concerning but still present hindrance, was the ability to effectively view documents or enter information into devices with a small screen, or otherwise be required to carry around a bulky device with a larger screen (Fiatech, 2012). The next moderately concerning aspect regarding the physical characteristics of technology related to the adoption of IT, was that face-to-face communication would be significantly reduced or lost. In some instances, the necessity of face-to-face communication is heavily relied upon by field personnel; an example of this is expressed by the superintendent who preferred discussing onsite safety with craftsmen in person. Finally, the absolute and complete reliance on IT was the aspect that most concerned field personnel about the physical characteristics of IT, that is completely eliminating paper-based methods. These concerns derive from the potential failure of technology. In these instances, when technology fails and information is inaccessible, projects will have to completely halt construction.

From a software capabilities standpoint, respondents indicated that an extensive range of facilitating and hindering features affect their daily activities. The most

prominent facilitating features observed were current technology's ability to maintain consistency of information, automatically sort and organize that information, and redistribute that information to various project stakeholders. These capabilities supplemented decision-making in the field and reuse of information during meetings with various stakeholders. These software features also allowed field personnel the ability to analyze trends of information which they could later use in the field or at the office during meetings and decision making processes. An example of this was scene with the field engineer who referenced procurement times on past projects to estimate anticipated procurement times on his current project. The flexibility of some programs, which allowed users to manipulate and develop their own task-specific documentation, was praised by several interview respondents. Conversely, in a few instances, when programs were too complicated or rigid, it was found to hinder respondents daily processes. Software that was too complicated sometimes created barriers amongst stakeholders who couldn't utilize the program properly. When the software interface was too rigid, it made it difficult for users to enter necessary task-specific information. Another important problematic function was when the search functions of the software were not "user-friendly". This often led to lost time accessing information. In one case, it deterred a superintendent from using software who then reverted back to paper-based methods for some of his daily practices.

Further research should be performed surrounding the how software can be better integrated into field personnel's daily tasks (O'Brien et al., 2011). Moreover, software interfaces need to be designed to better fit field personnel's data collection procedures.

Given the respondent's feedback on current software, a more well-balanced interface would be complementary to field personnel's needs; focus areas should include features that provide a software that offers required data fields, uncomplicated search capabilities, and simultaneously offers some flexibility to users to manipulate the interface and enter their own preferred task-specific data.

Chapter Six: Conclusions and Recommendations

The results of the survey, interview, and IT training and evaluation exercise provide empirical evidence that contradict or offer further clarity to several existing perceptions based around the adoption of IT at the site level. This section summarizes those findings at they pertain to the research objectives. Recommendations for future research that will supplement the findings of this study and further support the adoption of IT at the site-level are also provided.

Review of Research Objectives

As stated in Chapter One, there are two main objectives that pursued by this study; how each objective was met is described below:

- **Objective One: Investigate the current state of general usage and skill-level of IT by site-level personnel in the construction industry.** Typical construction artefacts and technologies available to site personnel that assist them in their daily tasks were identified through literature. A survey was then deployed that gauged the extent to which site-level personnel develop their artefacts electronically to supplement their daily tasks and estimated their proficiency with available general purpose and construction-related technologies. From this effort percentages of site-level personnel who use and are proficient with different technology applications were determined. This was observed as a likely representation of the current state of use and skill-level of IT by site-level personnel in the construction industry as a whole.

- **Objective Two: Investigate the impacts of IT when applied to site-level activities and identify potential barriers to the adoption of IT by site-level personnel in the construction industry compared to previous viewpoints.** Information from the survey was utilized, and an interview was developed and deployed that inquired about field personnel's daily routines and tasks, and how the use of IT impacted these practices. An IT training and evaluation exercise was also pulled from a separate stream of research that showed how an introduction to the benefits of a technology and how an increase in proficiency of a tool can influence the acceptance and adoption of a technology. Together, these references allowed the author to interpret barriers associated to the adoption of IT at the site-level based on independent and dependent factors; where the independent factors encompass user-related and industry environment aspects related to technology adoption, and dependent factors encompass technology capabilities and their effectiveness.

Limitations

Limitations associated with this study include:

- The survey study focuses on semi-automated construction technology tools from a generic standpoint. The use of fully-automated tools such as laser scanning or GPS systems to supplement site-level personnel's activities was not included.
- The survey and interview study responses mostly involved personnel from large companies, approximately with 1000+ employees. Thus, the results of the survey

are more representative of large companies within the construction industry, rather than the industry as a whole. Further, research surrounding this topic needs to be performed on medium and small-scale companies.

- The interviews were limited to four companies. This creates potential redundancy in the results and restricts the potential for the results to be representative of the entire construction industry; limiting the potential to fully capture all independent and dependent factors that currently affect IT adoption at the site-level. With the limited number of companies involved there is an increased likelihood that respondents within these companies are contained by similar circumstances and are more likely to provide analogous examples and experience comparable technology issues.
- The IT training and evaluation exercise was limited to three respondents within one company. Similar to the interviews, this creates potential redundancy in the results and limits the potential for the responses to be representative of the entire construction industry.

Contributions

This study offers an important contribution to the body of knowledge surrounding the construction industry, specific to the area of construction technology use and development practices. Prior to this study, minimal research surrounding the current state of technology use at the construction site-level was available. Furthermore, to the author's knowledge, little empirical evidence in the past has been provided surrounding the

reasoning for adopting or not adopting technology in construction at the site level. The key contributions are highlighted below:

- The current state of site-level personnel's IT usage and skill-level in the industry is provided. This offers a point of reference when gauging the adoption of site-level semi-automated technologies in future studies.
- Through this study "areas of improvement" related to technology acceptance and development within the industry are offered that if researched and resolved may facilitate adoption of technology by site-level personnel. The "areas of improvement" are based upon:
    - How site-level personnel are currently adapting to technologies compared to traditional paper-based methods.
    - How technology currently fits into field personnel's daily routines and activities.
    - What the most prominent user and construction industry-related barriers are connected with IT adoption that currently exist in the industry.
    - What considerations need to be made during the development of future construction technologies, given current positive and negative technological effects to field personnel’s daily activities.

Conclusions

Rather than site-level personnel's resistance to accept IT, the most prominent barriers that significantly hamper the adoption of IT in the current industry surround the

skill-level of users and business-related limitations. At large, site-level personnel are accepting of tools that may further facilitate their daily routines and tasks. However, their proficiency related to technology is essential. In instances where lack of basic IT skills hinder task productivity or relaying of information, site-level personnel may consciously limit their use if IT or be forced to return to paper-based methods, so as not to negatively affect their team's efficiency. Site-level training may present a viable solution to this particular barrier. Further research should be performed that allows for industry administrative staff to make effective decisions on how this type of training may be best implemented. Projects and companies who confine the implementation of technology also significantly limit site-level personnel's ability to adopt IT. Project IT restrictions are often driven by the availability of highly sensitive information onsite and the associated security measures set in place by clients. In other instances, company culture and employers restrict usage. The customs of a company may not require routine IT usage given that they have deeply engrained paper-based processes. Some companies simply do not provide their site-level personnel the means to engage IT in their daily tasks; necessary task-related hardware and software are not made available to these employees. The basis for and ability to overcome these restrictions were not covered in this study. Surrounding these aspects of the industry are essential "areas of improvement" that need to be better understood and researched to improve adoption of IT at the site level.

Not as essential, but still hindering to the acceptance and adoption of IT are the attributes and characteristics of technology. Site-level personnel's jobs take place in a dynamic working environment, in that sense added complexity to their routines through

the use of IT can quickly become disruptive. Features of some hardware and software are simply not as effective as they should be and create additional steps in site-level personnel's work; examples of this include when program interfaces are too rigid, limiting site-level personnel's abilities to manipulate the software so that they may enter essential information, and when the search capabilities of software are unable to readily access critical project information. Another example includes when the complexity of a technology requires specific training, making it uninterruptable to inexperienced personnel which may be subcontractors or the client.

Previous industry perceptions have "pointed the finger" at site-level personnel as the main hindrance to the adoption of IT during construction; particularly their overall resistance to change, reluctance to accept IT, and low level of IT literacy have been determined as key barriers. Although barriers to technology adoption at the site level exist, they do not directly align with these aforementioned industry perceptions. The current state of technology adoption in the industry at the site level is quite advanced. As a group, the majority of site-level personnel have in many instance adopted a wide range of technology to supplement their daily routines and practices. Further adoption will be influenced by the industry's ability to overcome the barriers highlighted in this study.

Recommendations for Future Research

Based on the findings in this research, the following are recommendations for future research that may be performed to further this body of knowledge:

- Further research surrounding the adoption of technology by small and medium-sized companies at the site-level should be performed to establish if the findings in this paper align with companies of all sizes within the industry.
- Site-level personnel often directly and indirectly alluded to the use of training to further their techology proficiency and increase their effective use of technology. Futher research surrounding the basis for why formal training is not a wide spread practice at the site-level should be performed. Supplementally, what the most affective forms of training are at the site-level should be studied.
- Further research surrounding the restrictions set in place by particular industry projects and companies needs to be assessed. Specifically, how those restrictions can be overcome to facilitate the adoption of IT at the site-level need to be studied.
- Further research surrounding the restrictions set in place by company culture need to be assessed. Specifically, how those restrictions can be overcome to facilitate the adoption of IT at the site-level need to be examined.

Appendices

Appendix A: User-End Requirement Survey

A.1 Survey Questionnaire

Construction Background

1. Approximately how many years have you been in/or been involved with the Construction Industry? _____

2. What is the name of the COMPANY/ORGANIZATION you work for? _____

3. How many full-time employees currently work for your organization?
    a. 0-100
    b. 101-300
    c. 301-1000
    d. 1000+

4. At which location do you work?
    a. North America
    b. Europe
    c. Other: _____

5. What is the primary role(s) of the ORGANIZATION you work for? Select one or more roles from the list below.
    a. Owner
    b. EPC
    c. General Contractor
    d. Architecture
    e. Engineer
    f. Specialty Contractor
    g. Material Supplier
    h. Equipment Supplier
    i. IT Supplier
    j. IT Consultant
    k. Other: _____

6. What is your job function?
    a. Project Administrator
    b. Field Engineer
    c. Superintendent

d. General Foreman
e. Other: _____

7. What is your work setting?
   a. At the project site (mostly in the site office)
   b. At one particular site (mostly out on the site)
   c. Other: _____

Work Activities

8. On an average project, what percentage of your time do you usually spend:
   a. Supervising field activities? _____%
   b. Meeting project stakeholders? (e.g. Subcontractors' meeting, safety meeting, informal meetings) _____%
   c. Working independently at the office? _____%
   d. Other _____%

   TOTAL 100%

9. Regarding the time you spend working independently, how do you divide your time?
   a. Filling out necessary paperwork _____%
   b. Developing documents to support my meetings and inspections _____%
   c. Doing research for different building components, equipment, materials or activities _____%
   d. Other _____%

   TOTAL 100%

10. How much time do you spend trying to access information from electronic sources?
    a. Not much. I rarely find problems when trying to access a document or page
    b. A little. For the most part, it's not very difficult to find what I'm looking for.
    c. A moderate amount. It can be time consuming trying to find the right document or page
    d. A lot. It can be troublesome to find the program or file that contains what I am looking

Work Documents

11. In a typical work week, how often do you update these documents yourself?

	Frequency (times a week)				*Method of update*	
	Less than 1	1-2	3-5	More than 5	By hand / notes	On a computer
a. Forms and lists						
b. Own sketches and drawings						
c. Spreadsheets and matrices						
d. Trend Charts						
e. Schedules and Look-aheads						

f. Meeting Agendas							
g. Plans and drawings							
h. Other:							

12. How likely are you to bring a computer or paper documents to meetings and site inspections?
    a. Very likely, I always try to rely on my current work documents
    b. Likely, these documents are good support in many instances
    c. Neutral, just when there are too many activities going on
    d. Unlikely, only when I am required to fill out certain forms or checklists
    e. Very unlikely, I avoid carrying documents around with me

Technology acquaintance

13. Please indicate your skill level

	Skill				***Frequency of use***			
	No skill	Begin-ner	Interme-diate	Expert	Everyday	Sometimes a week	Few times in a project	Never
Basic Hardware Desktops, Laptops, etc.								
Cell Phones, Radios, etc.								
Tablets PCs, GPS, iPhone, etc.								
Office Documents Presentations, Word processors, etc.								
Internet Resources Wikis, Blogs, online news, YouTube, etc.								
Spreadsheets Excel, Calc, Numbers, etc.								
Time/Task Management MS Outlook, E-Mail,								

iCalendar, Google Calendar, etc.								
Scheduling Primavera, Microsoft Project, etc.								
Advanced Scheduling Navisworks, Vico Schedule Planner, etc.								
2D/3D CAD AutoCAD, Unigraphics, Revit, etc.								

PLEASE INDICATE THE SOFTWARE YOU USE FOR THE FOLLOWING CONSTRUCTION ACTIVITES:

14. Design and Specifications:
    a. Distribution of the shop drawings, plans, specifications on the job site: _____
    b. Access to 3D-4D BIM models, navigate through them and update them: _____

15. Project Controls:
    a. Creating and tracking RFI's: _____
    b. Document exchange between field and office: _____
    c. Daily and Weekly Progress Reports: _____
    d. Photograph Capturing of daily work: _____
16. Quality:
    a. Access contract documents, QA/QC guidelines in the field: _____
    b. Inspect the status and quality of work and track inspection reports: _____

17. Safety:
    a. Incident Reporting: _____
    b. Document deficiencies with pictures, sketches, mark ups and electronic signatures: _____
    c. Communication of unsafe and hazardous conditions: _____

18. Material Management
    a. Track Material Location and Quantity: _____
    b. Material Delivery Status: _____

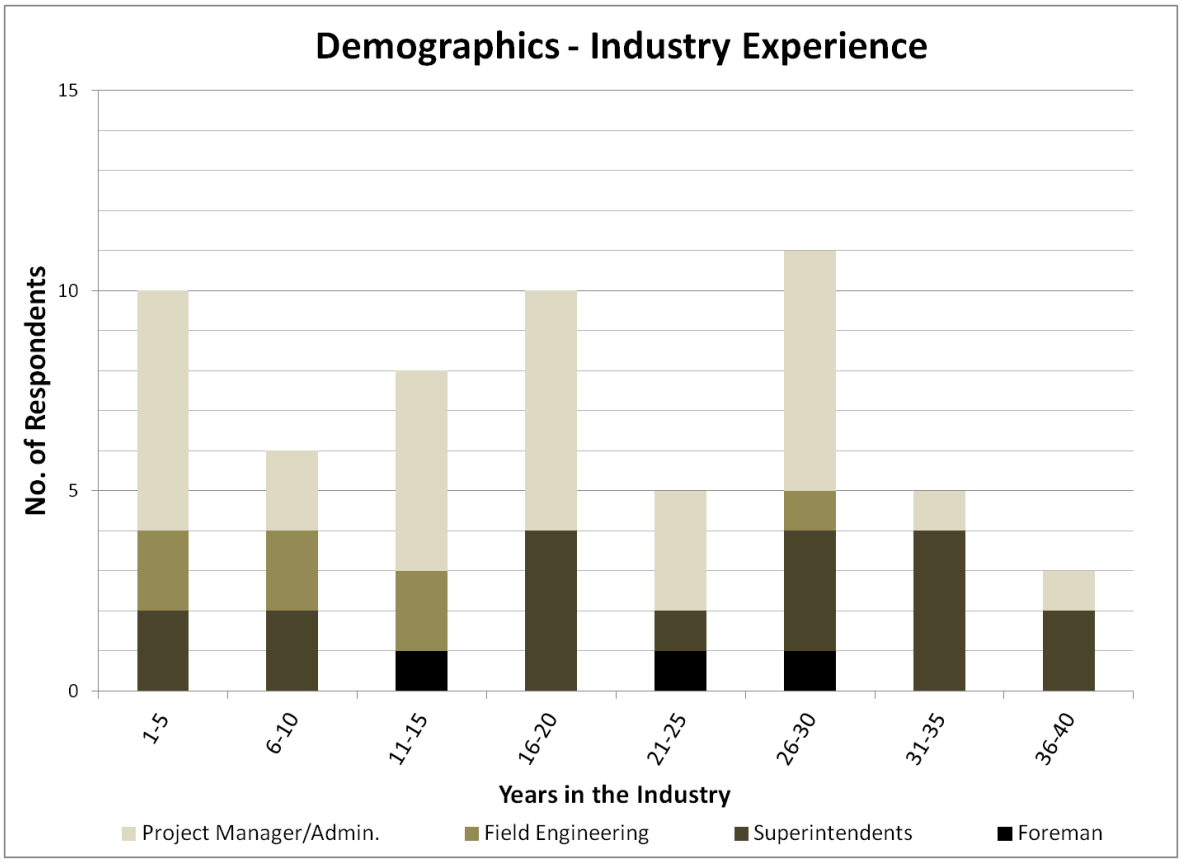
19. Project Delivery
    a. Punch List/Delivery Confirmation: _____
    b. Commissioning/Start-up and hand over: _____

20. Would you like to receive a copy of the results of this study? ❑Yes ❑No

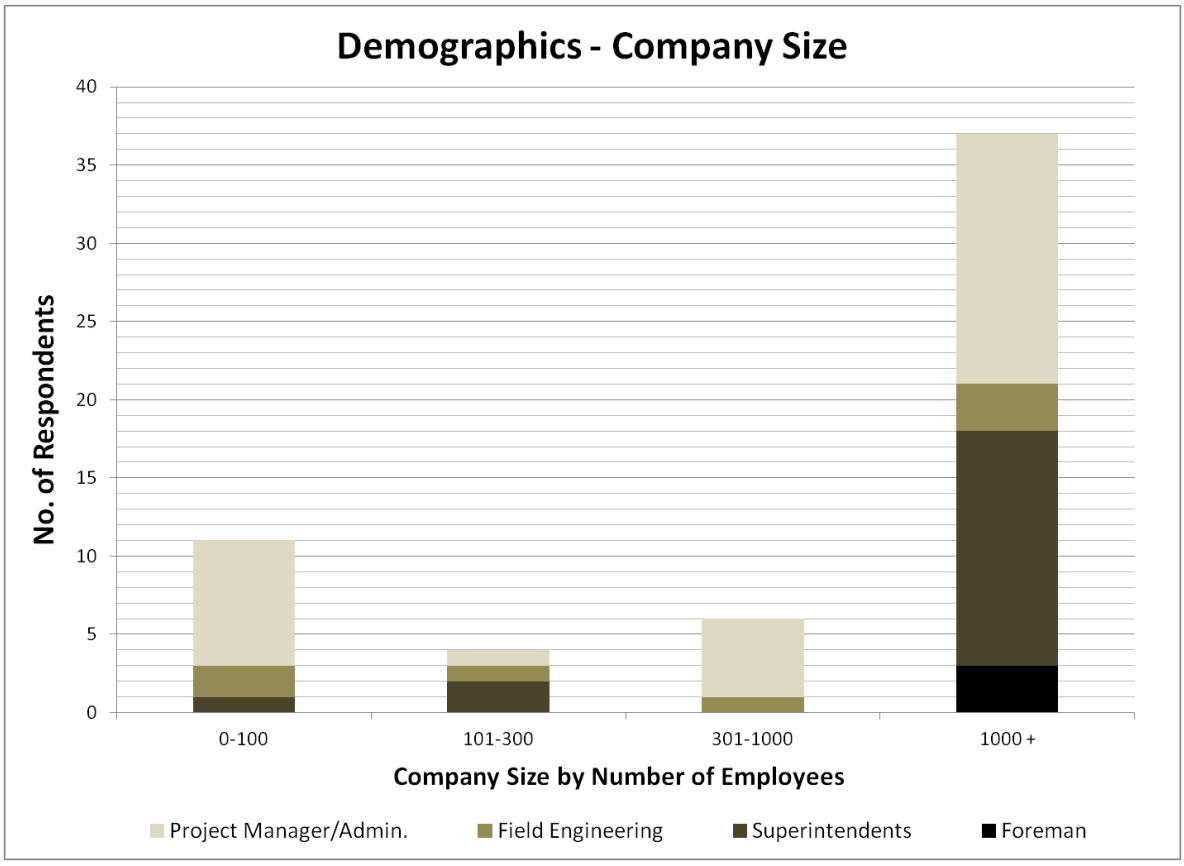
21. Would you be willing to be contacted by a graduate student for a follow-up interview of this study? If so, please provide your contact information below.

A.2 Survey Demographic Results

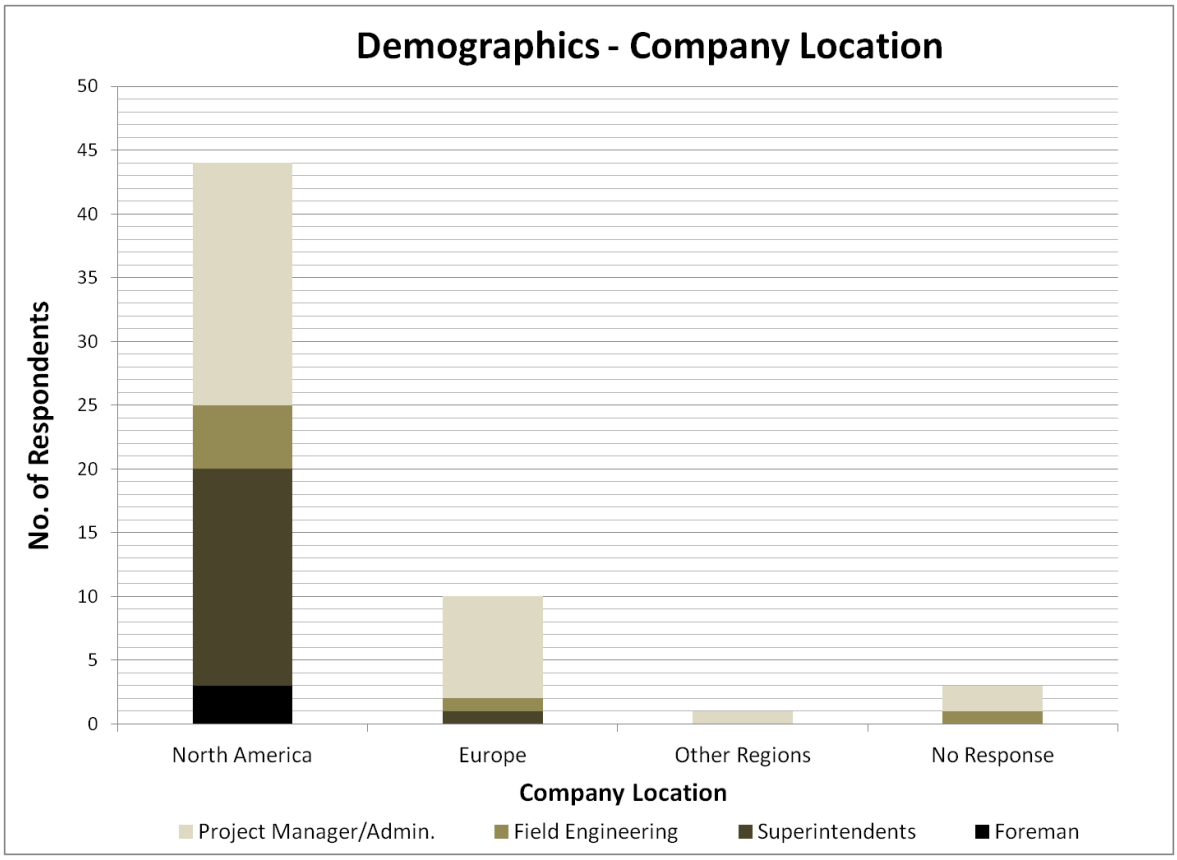
A.2.1 Position vs. Years in the Industry



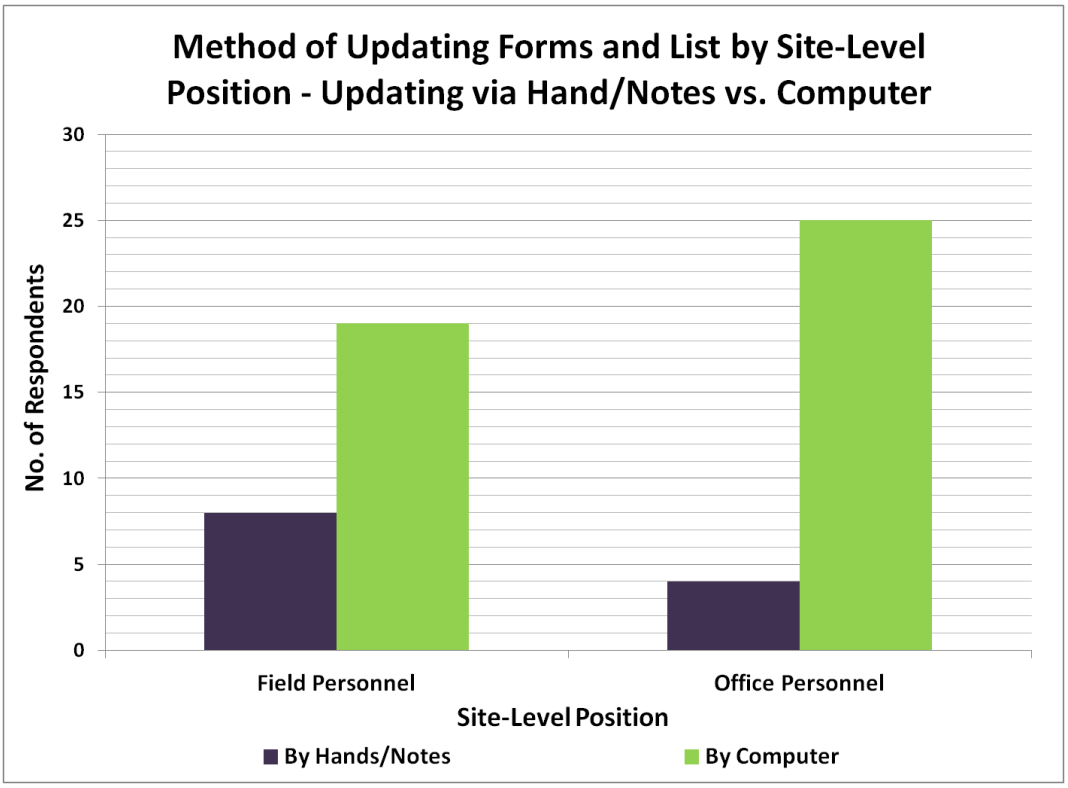
A.2.2 Position vs. Organization Size

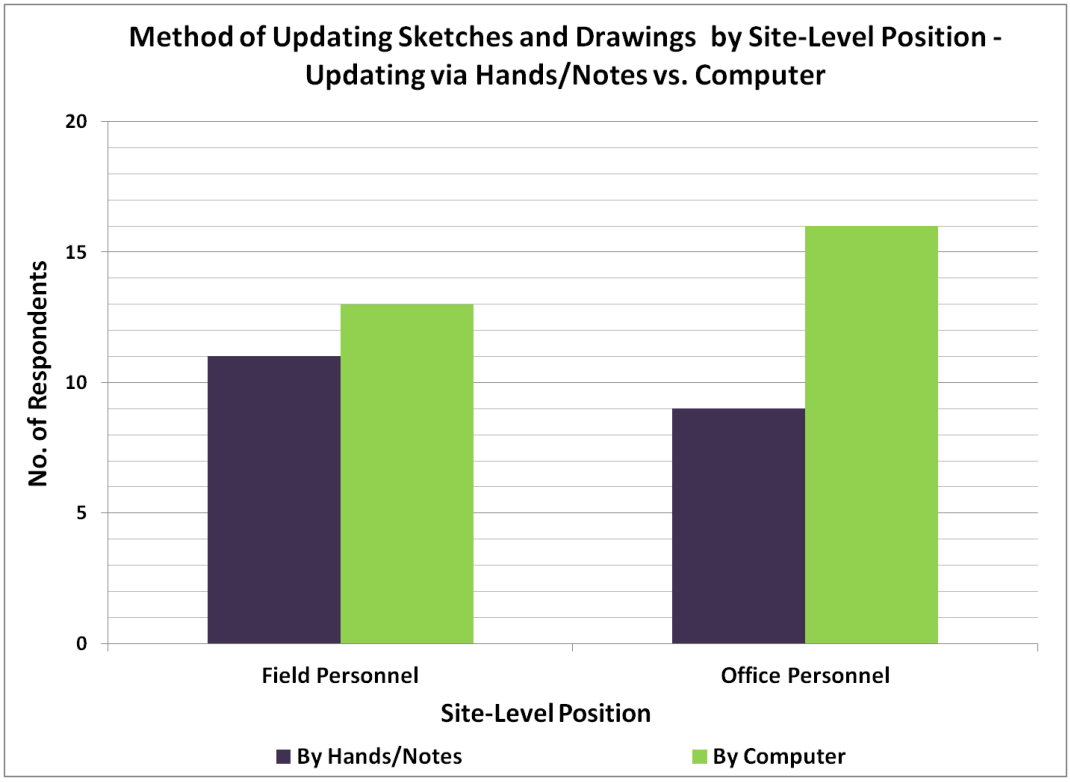


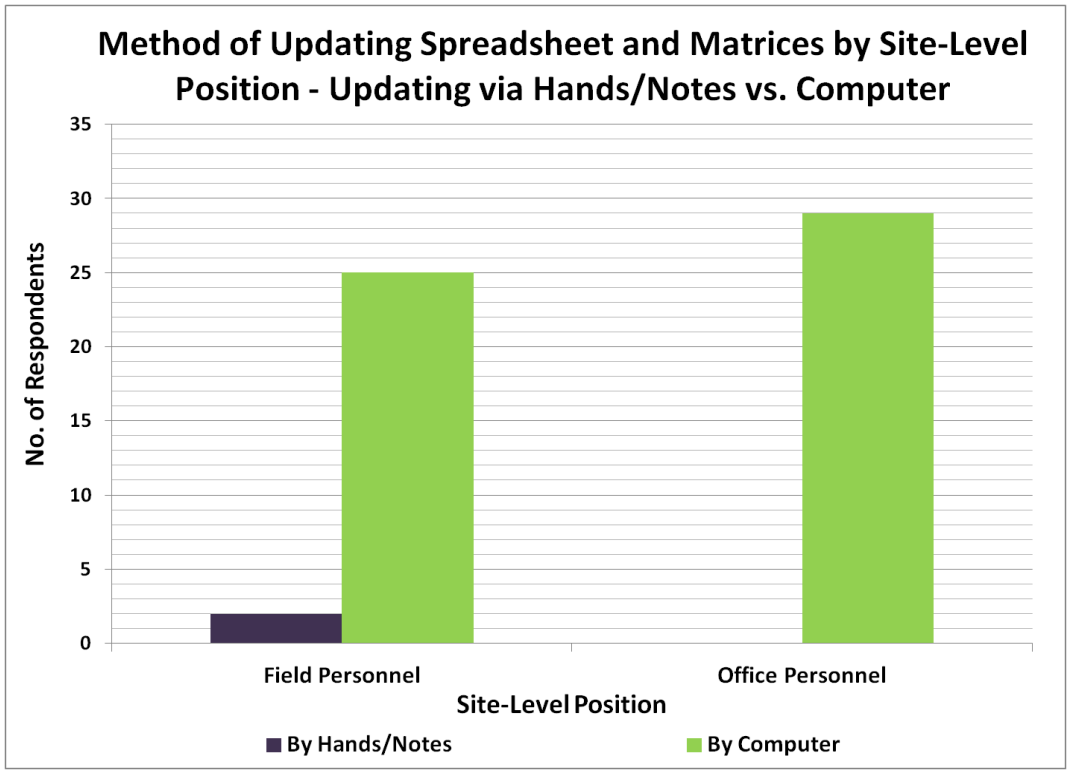
A.2.3 Position vs.Work Location

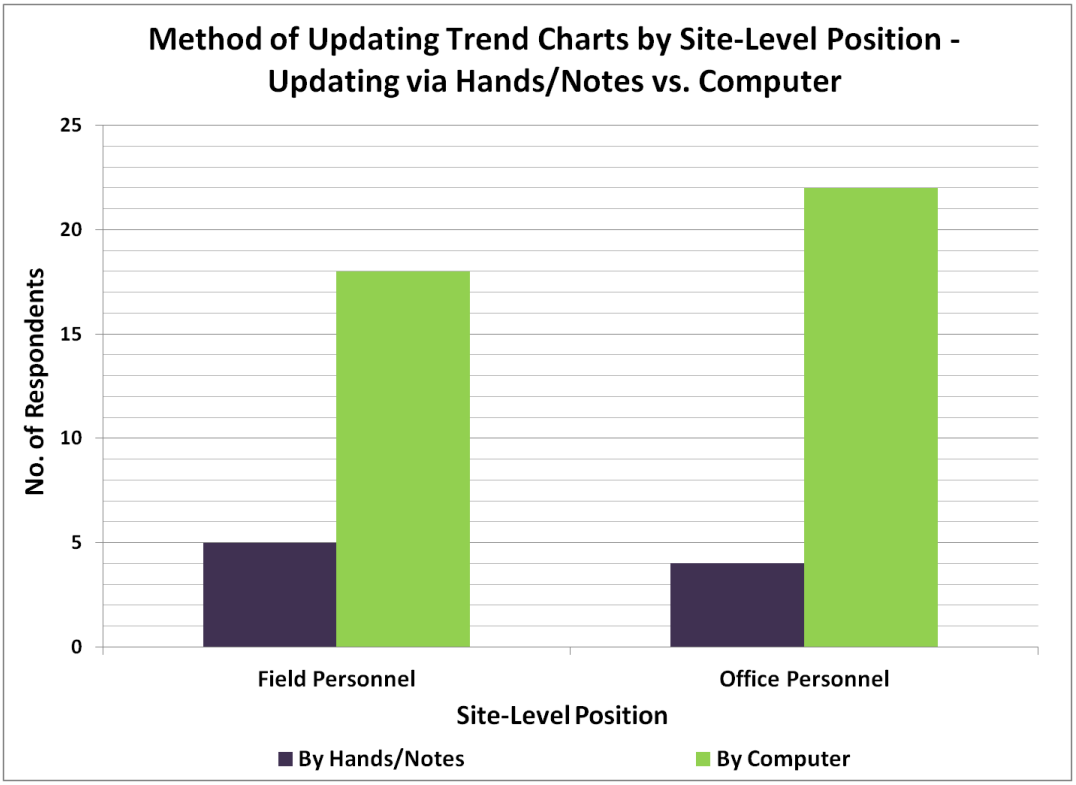


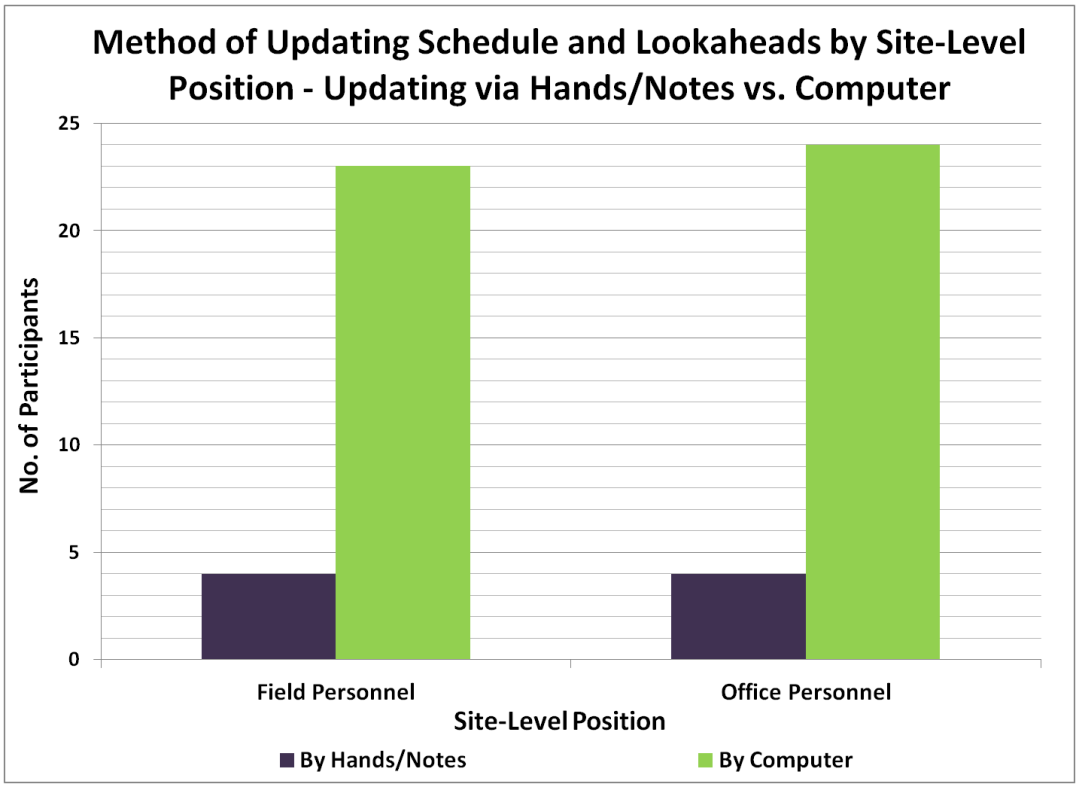
A.3 Results - Method of Updating Artefacts by Site-Level Position

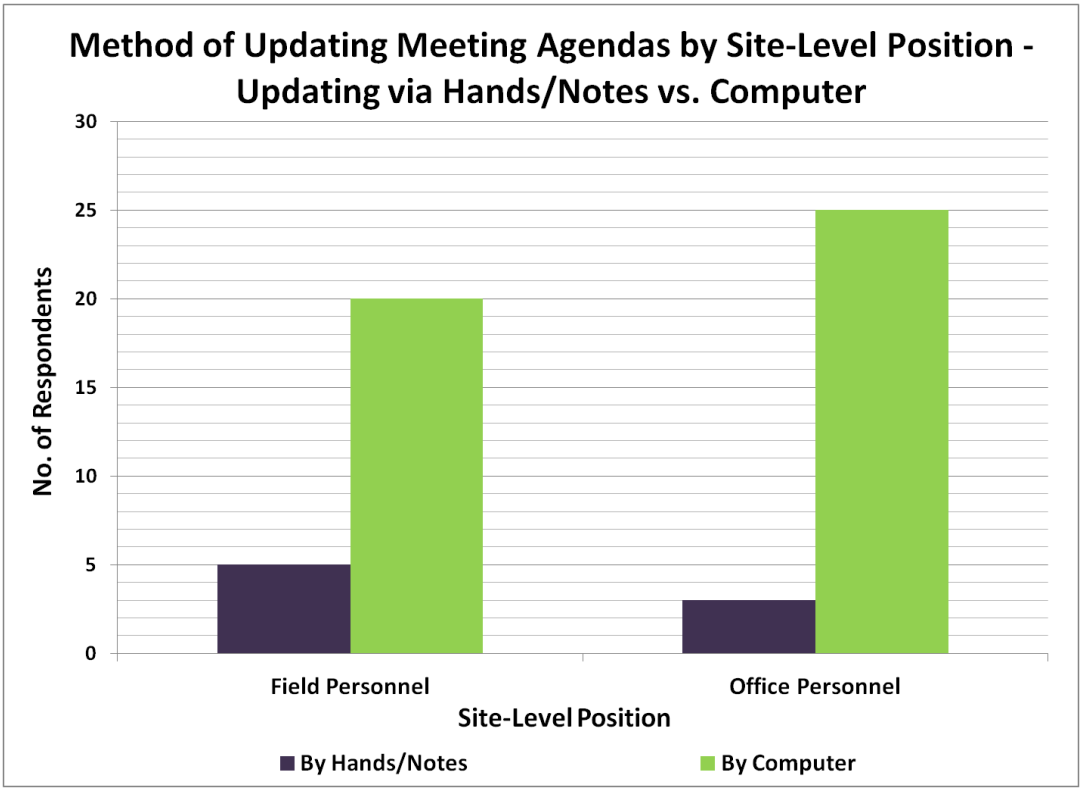


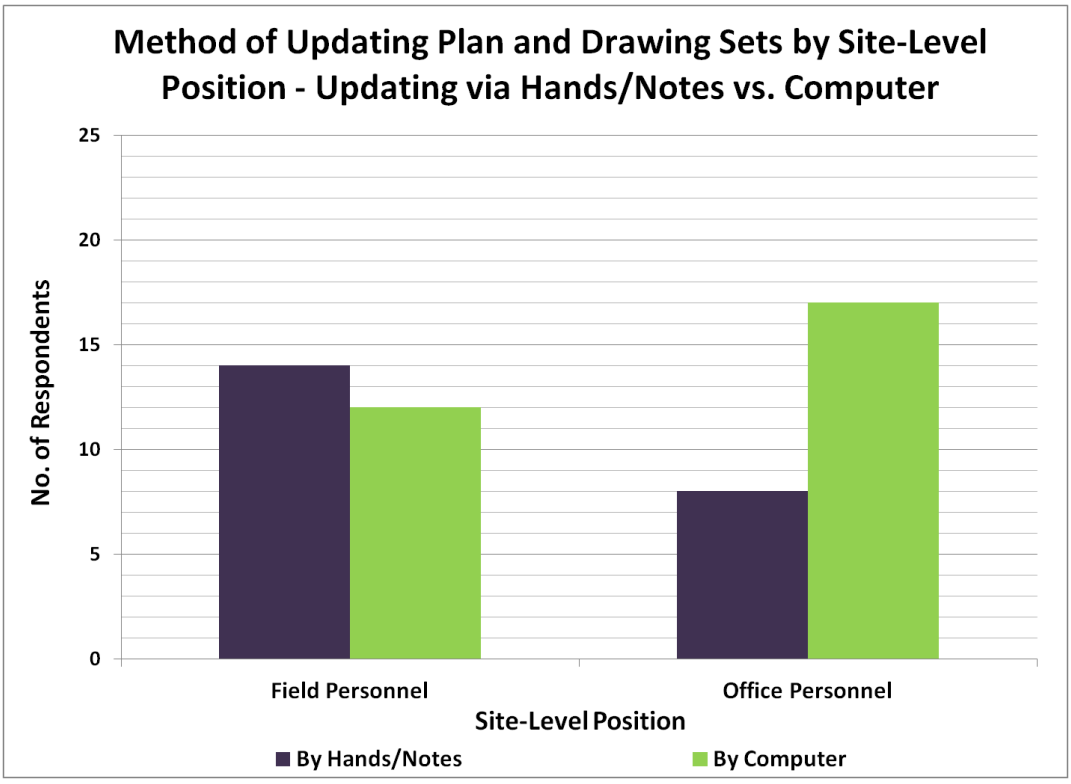

Method of Updating Sketches and Drawings by Site-Level Position - Updating via Hands/Notes vs. Computer
No. of Respondents
20
15
10
5
0
Field Personnel
Office Personnel
Site-Level Position
By Hands/Notes
By Computer


Method of Updating Spreadsheet and Matrices by Site-Level Position - Updating via Hands/Notes vs. Computer
No. of Respondents
35
30
25
20
15
10
5
0
Field Personnel
Office Personnel
Site-Level Position
By Hands/Notes
By Computer

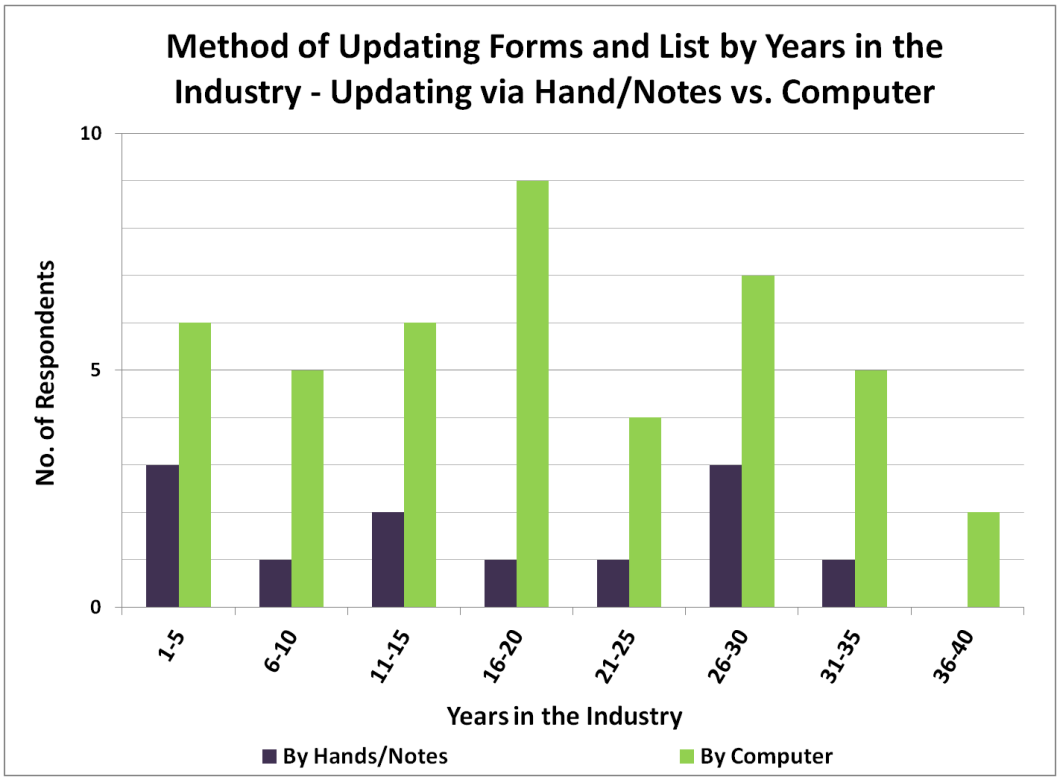

Method of Updating Trend Charts by Site-Level Position - Updating via Hands/Notes vs. Computer
No. of Respondents
25
20
15
10
5
0
Field Personnel
Office Personnel
Site-Level Position
By Hands/Notes
By Computer

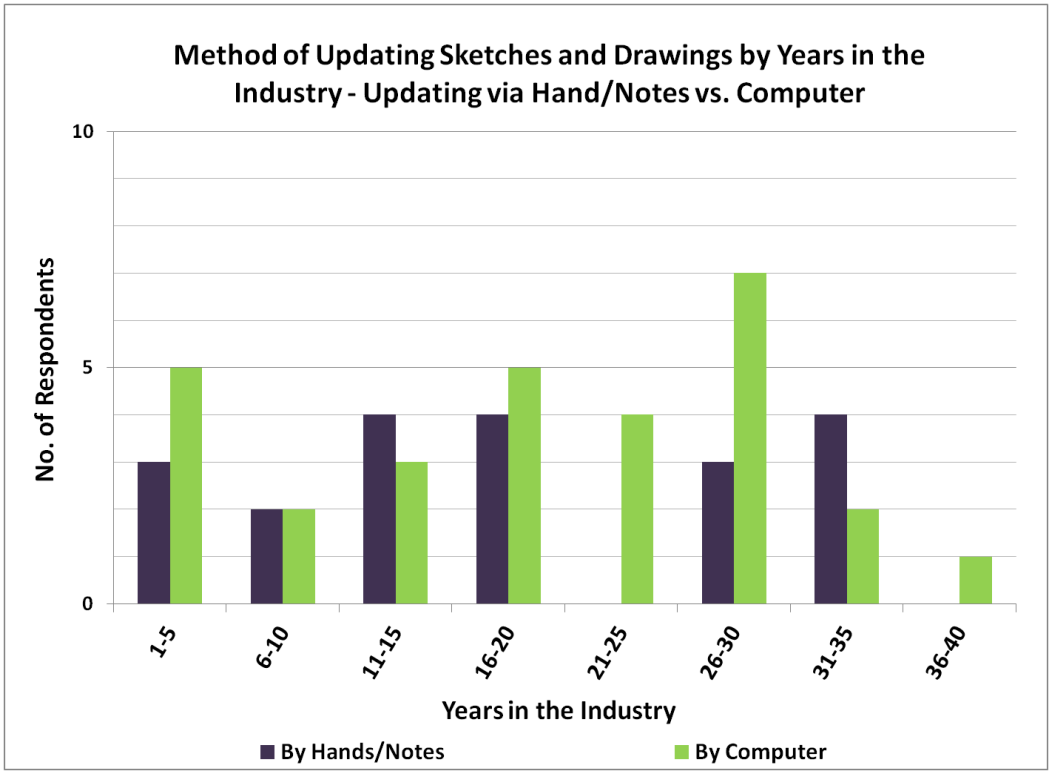

Method of Updating Schedule and Lookaheads by Site-Level Position - Updating via Hands/Notes vs. Computer
No. of Participants
25
20
15
10
5
0
Field Personnel
Office Personnel
Site-Level Position
By Hands/Notes
By Computer

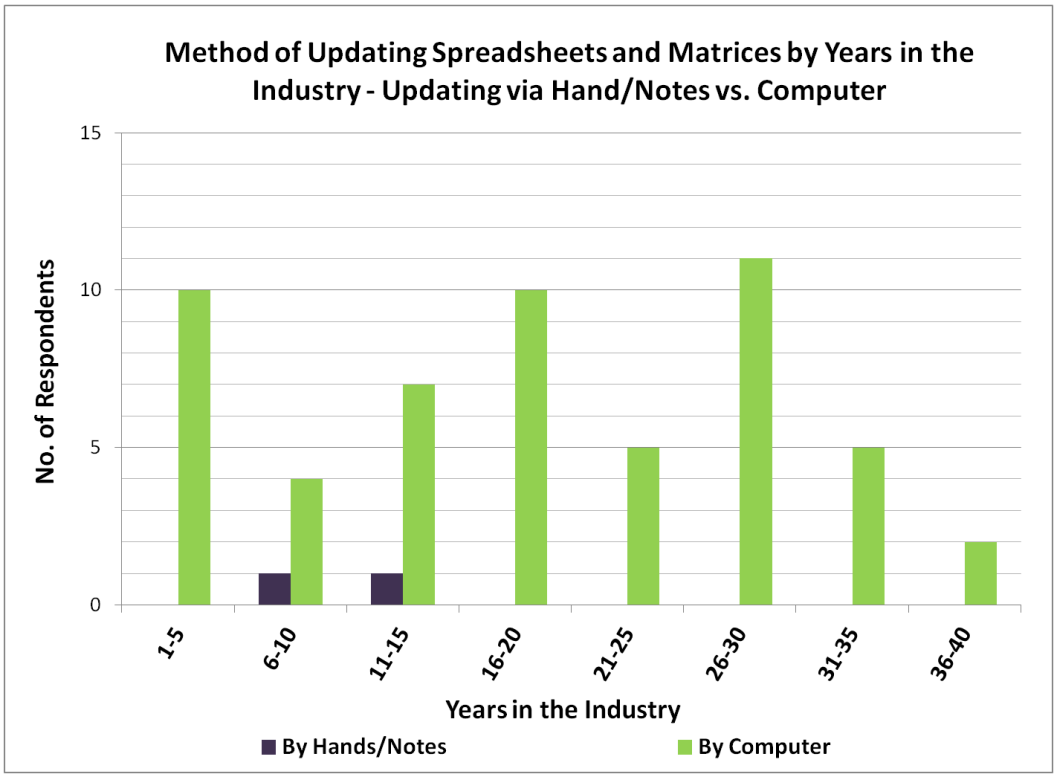

Method of Updating Meeting Agendas by Site-Level Position - Updating via Hands/Notes vs. Computer
No. of Respondents
30
25
20
15
10
5
0
Field Personnel
Office Personnel
Site-Level Position
By Hands/Notes
By Computer

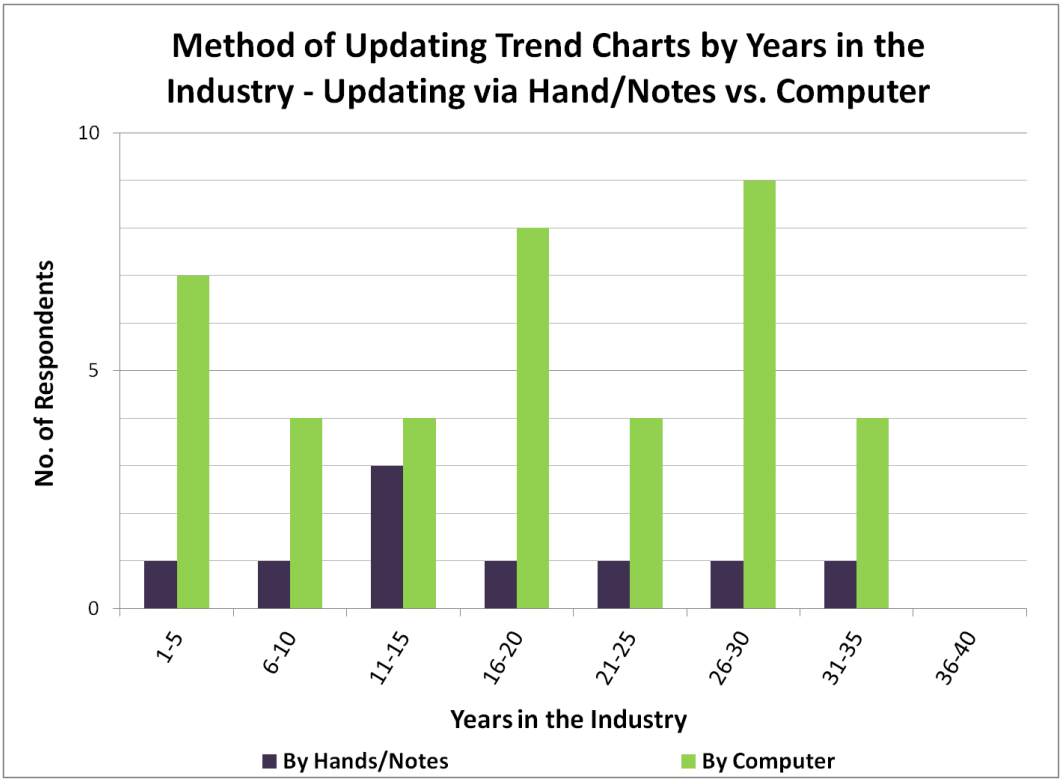

Method of Updating Plan and Drawing Sets by Site-Level Position - Updating via Hands/Notes vs. Computer
No. of Respondents
25
20
15
10
5
0
Field Personnel
Office Personnel
Site-Level Position
By Hands/Notes
By Computer

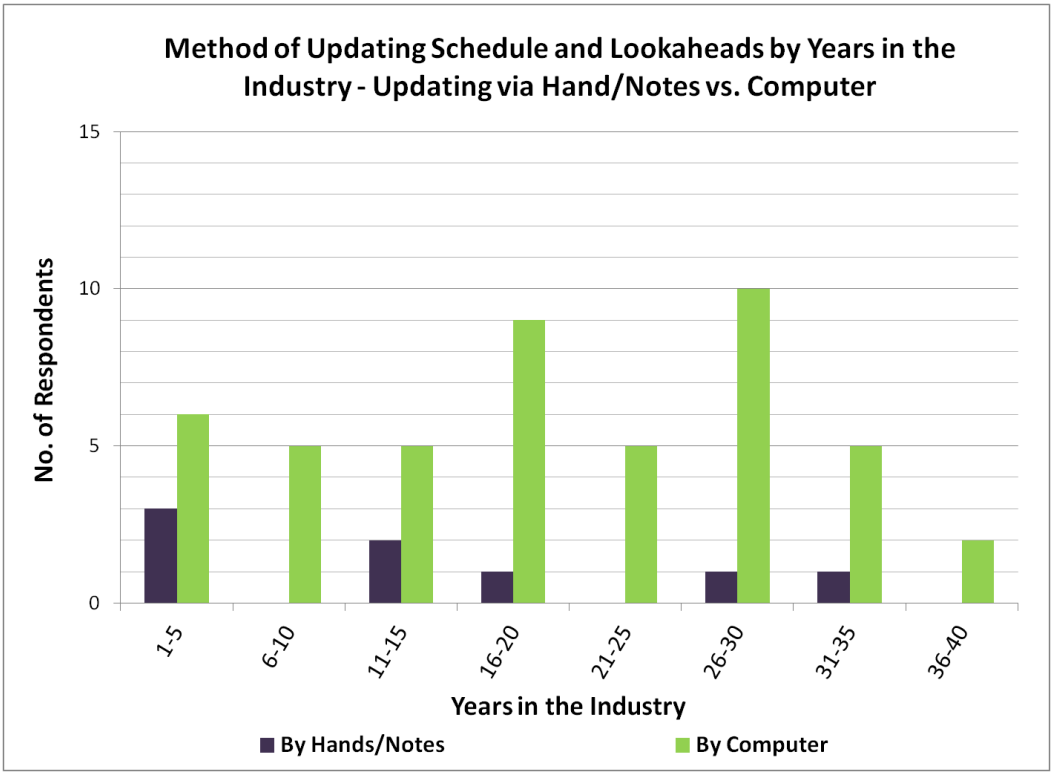
A.5 Results - Method of Updating Artefacts by Years in the Industry

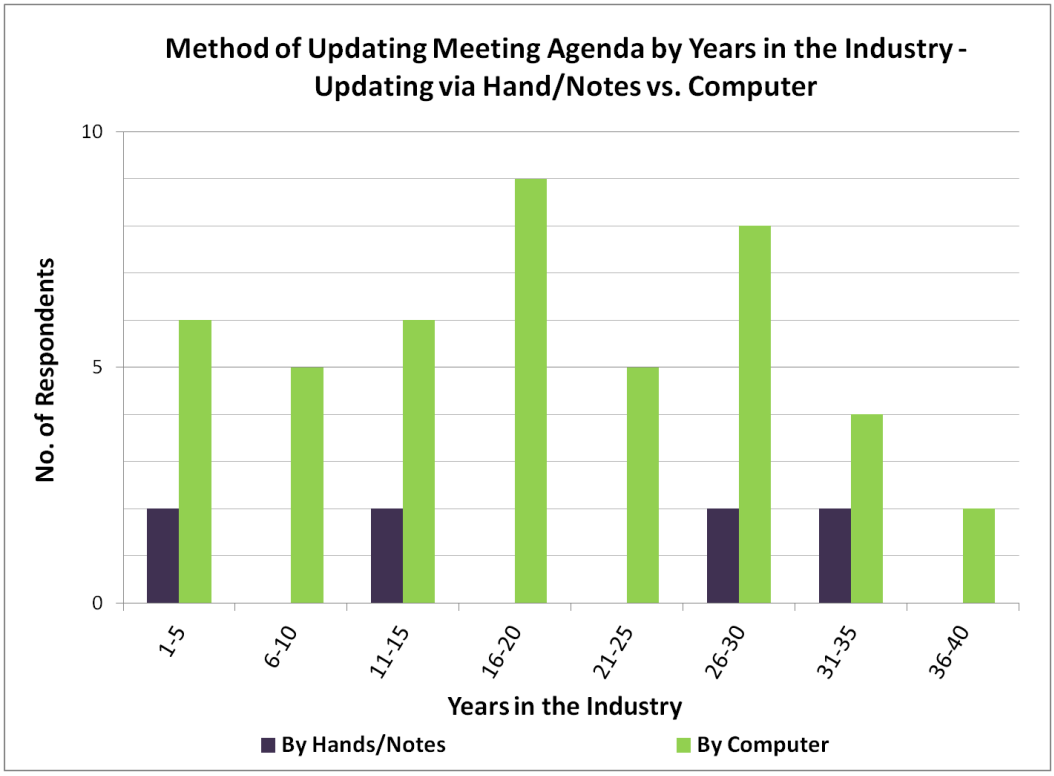


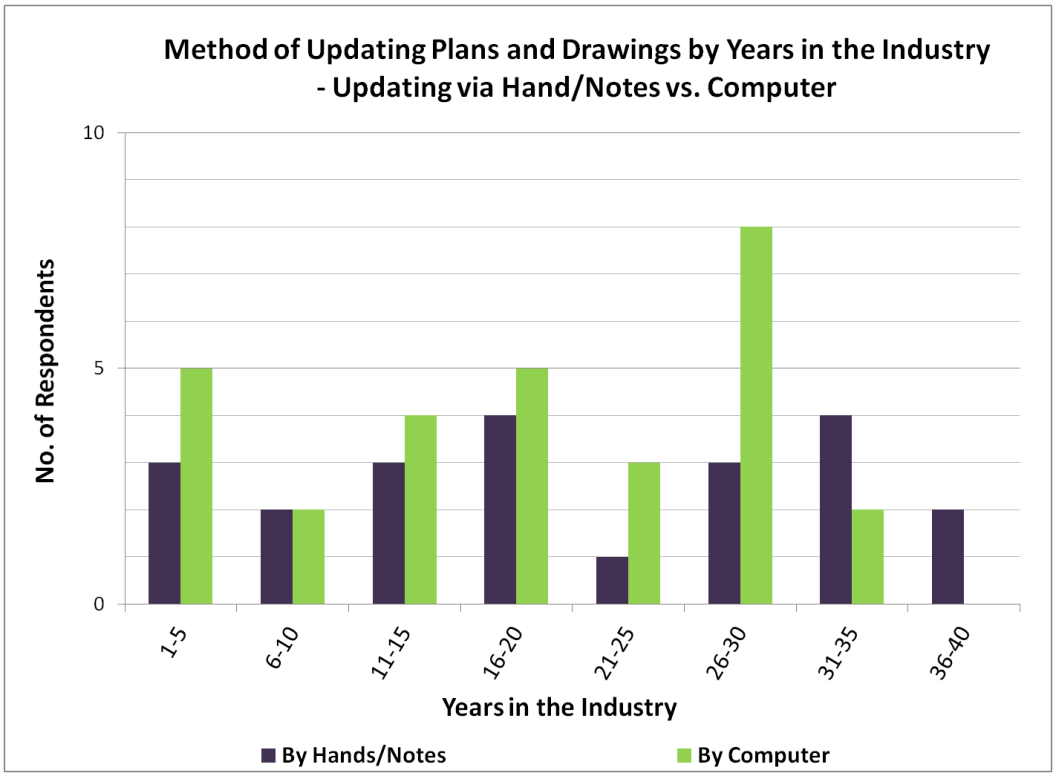

Method of Updating Sketches and Drawings by Years in the Industry - Updating via Hand/Notes vs. Computer
No. of Respondents
10
5
0
1-5
6-10
11-15
16-20
21-25
26-30
31-35
36-40
Years in the Industry
By Hands/Notes
By Computer


Method of Updating Spreadsheets and Matrices by Years in the Industry - Updating via Hand/Notes vs. Computer
No. of Respondents
15
10
5
0
1-5
6-10
11-15
16-20
21-25
26-30
31-35
36-40
Years in the Industry
By Hands/Notes
By Computer

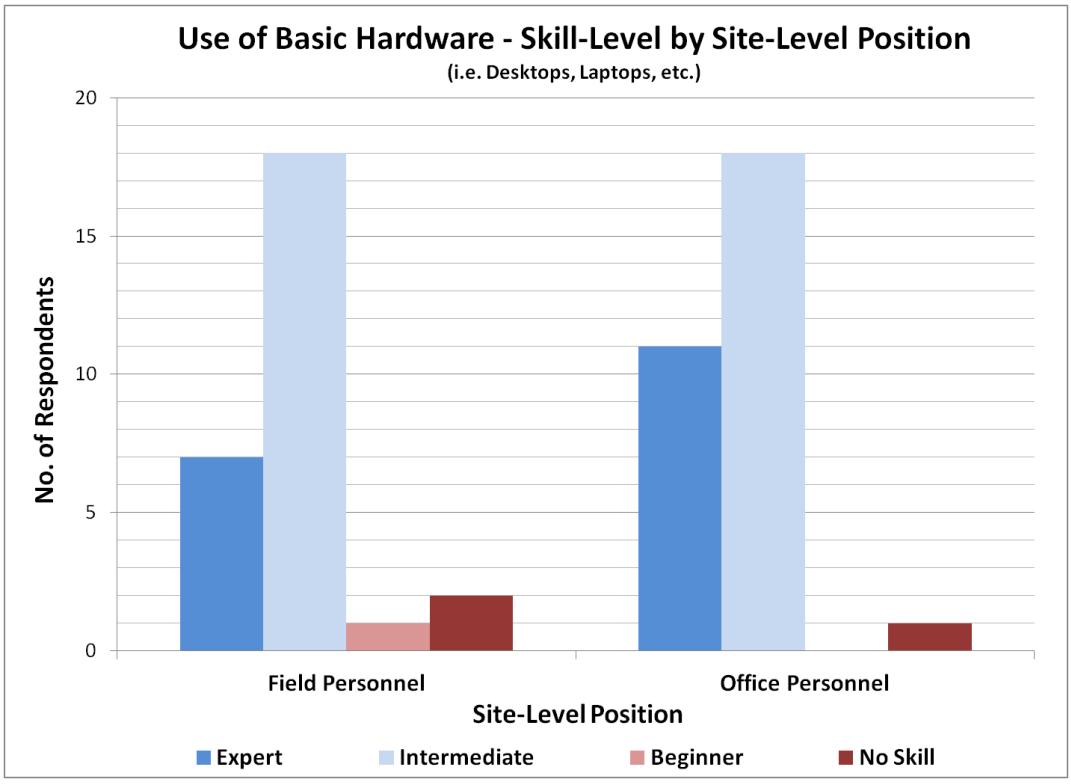

Method of Updating Trend Charts by Years in the Industry - Updating via Hand/Notes vs. Computer
No. of Respondents
10
5
0
1-5
6-10
11-15
16-20
21-25
26-30
31-35
36-40
Years in the Industry
By Hands/Notes
By Computer

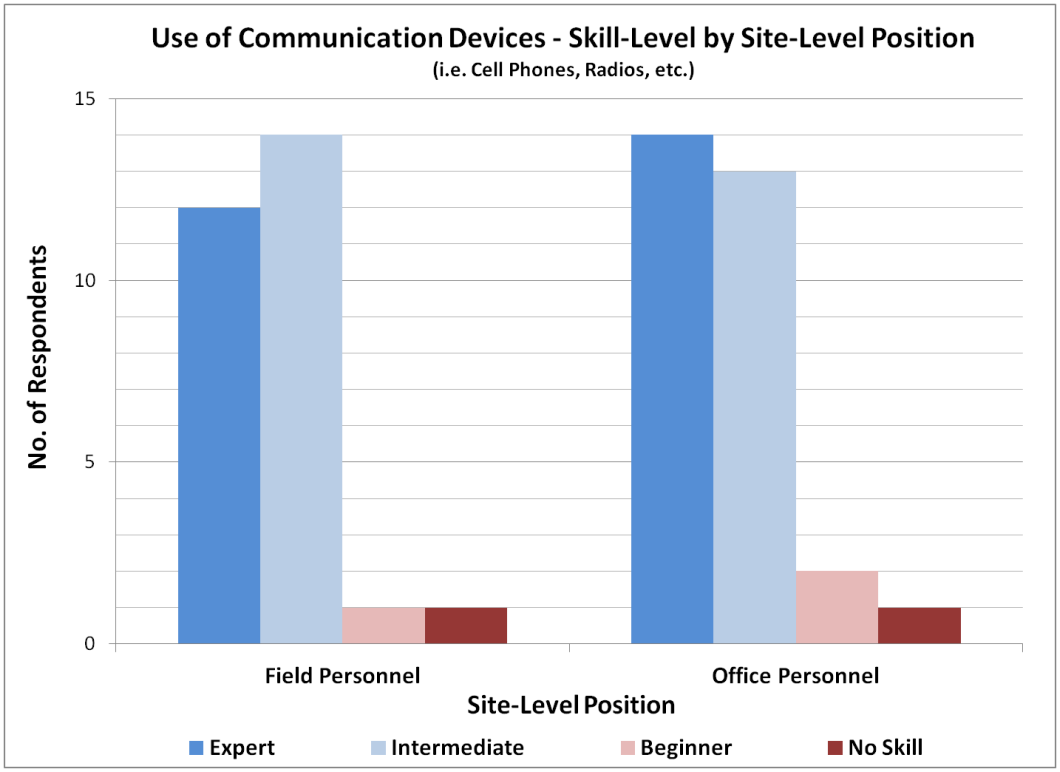

Method of Updating Schedule and Lookaheads by Years in the Industry - Updating via Hand/Notes vs. Computer
No. of Respondents
15
10
5
0
1-5
6-10
11-15
16-20
21-25
26-30
31-35
36-40
Years in the Industry
By Hands/Notes
By Computer

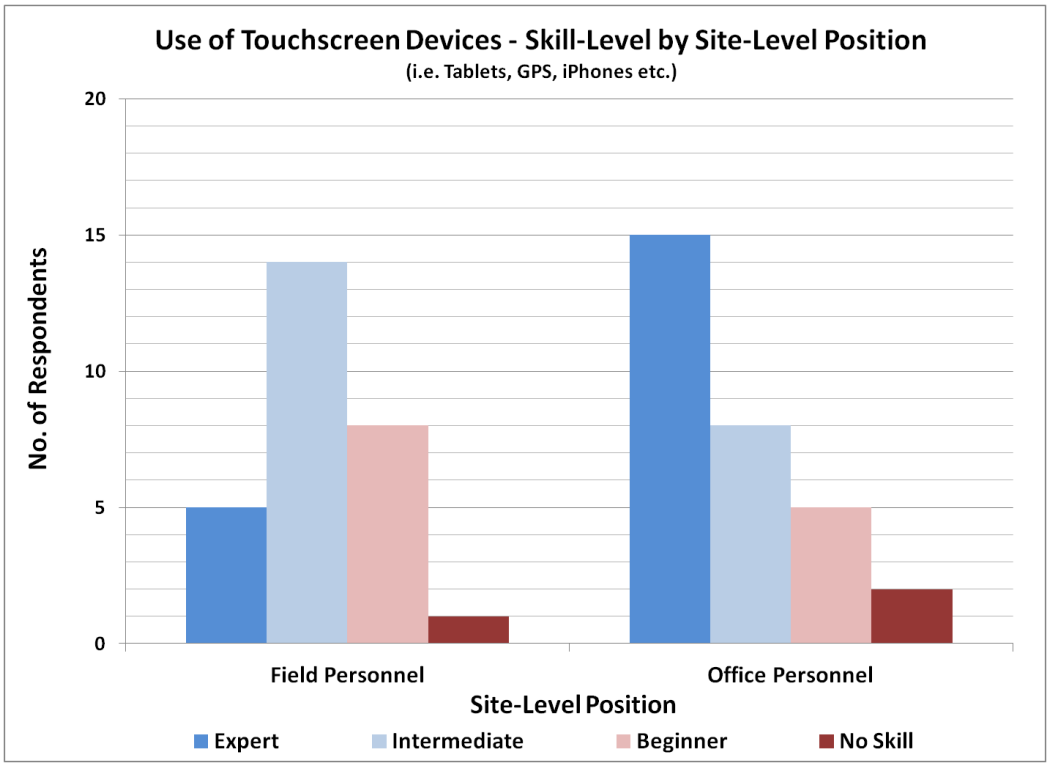

Method of Updating Meeting Agenda by Years in the Industry - Updating via Hand/Notes vs. Computer
No. of Respondents
10
5
0
1-5
6-10
11-15
16-20
21-25
26-30
31-35
36-40
Years in the Industry
By Hands/Notes
By Computer

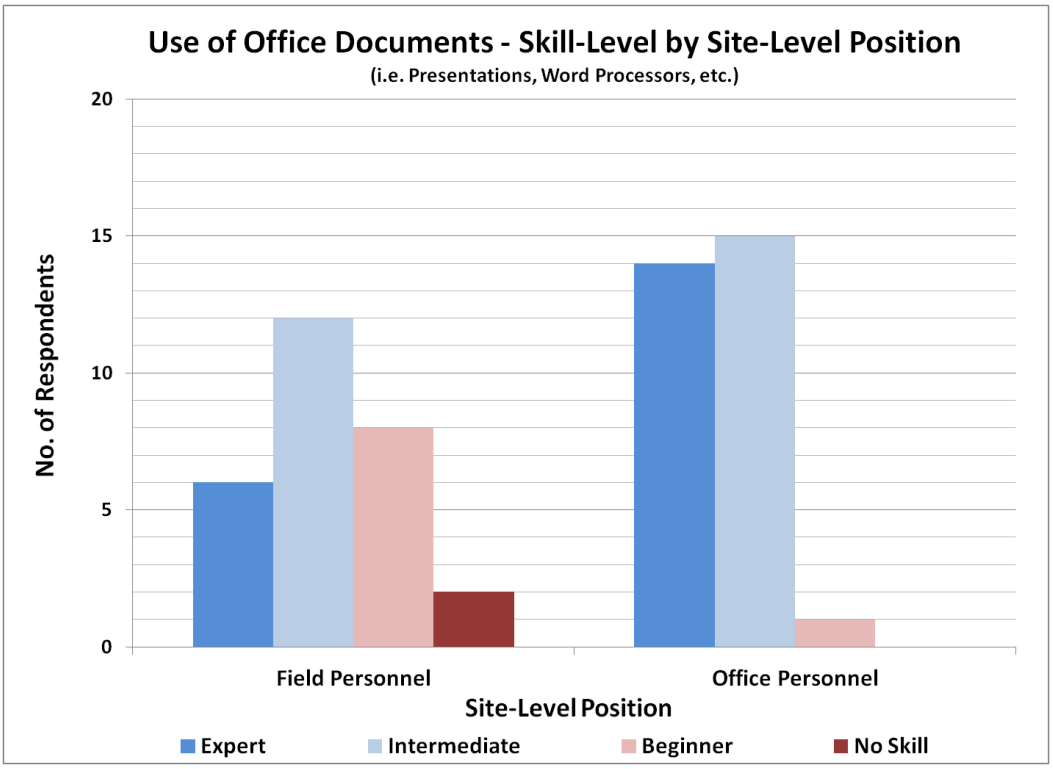

Method of Updating Plans and Drawings by Years in the Industry - Updating via Hand/Notes vs. Computer
No. of Respondents
10
5
0
1-5
6-10
11-15
16-20
21-25
26-30
31-35
36-40
Years in the Industry
By Hands/Notes
By Computer

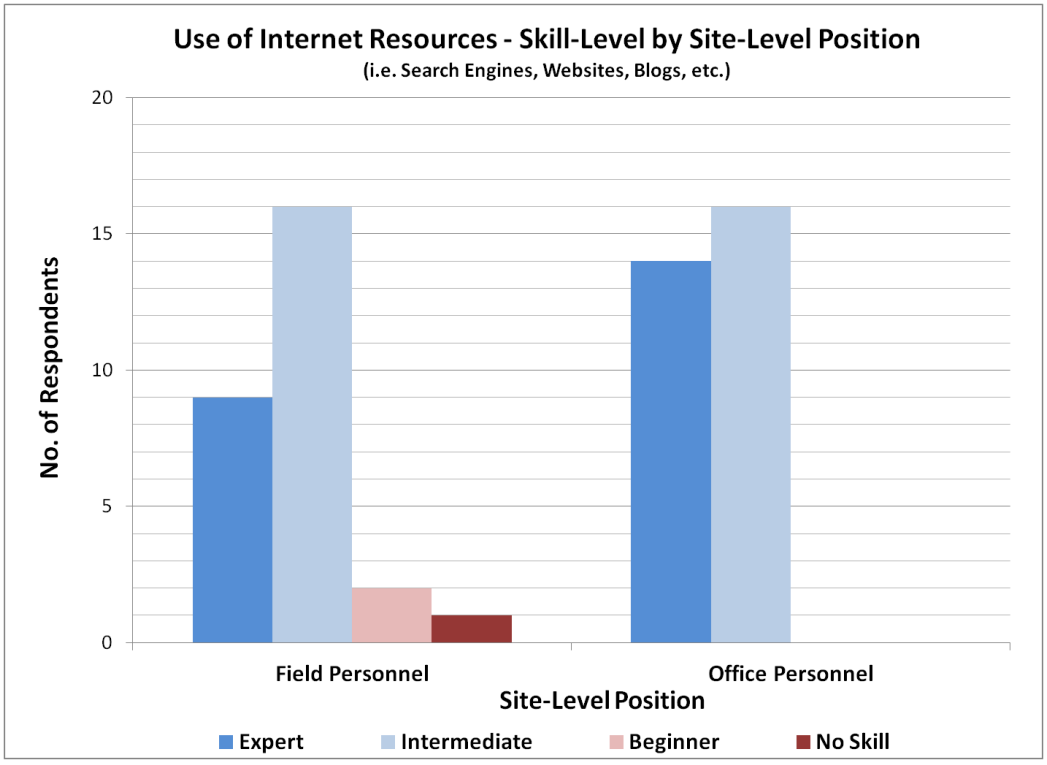
A.5 Results - Skill-Level of IT Tools by Site-Level Position

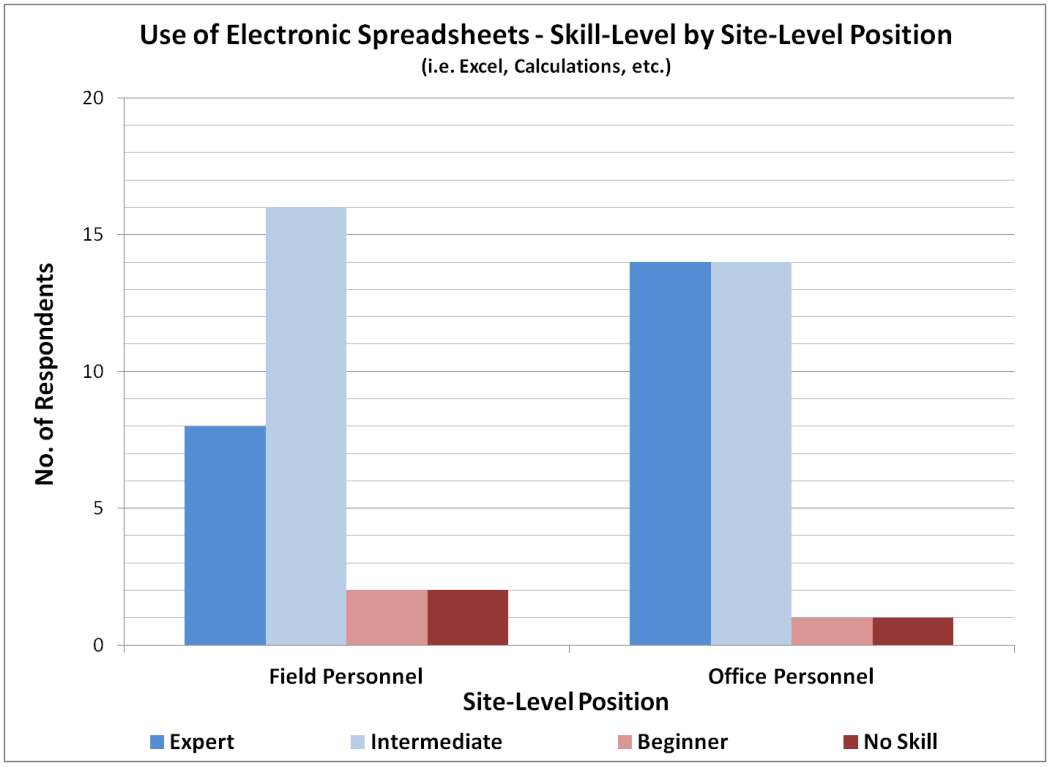


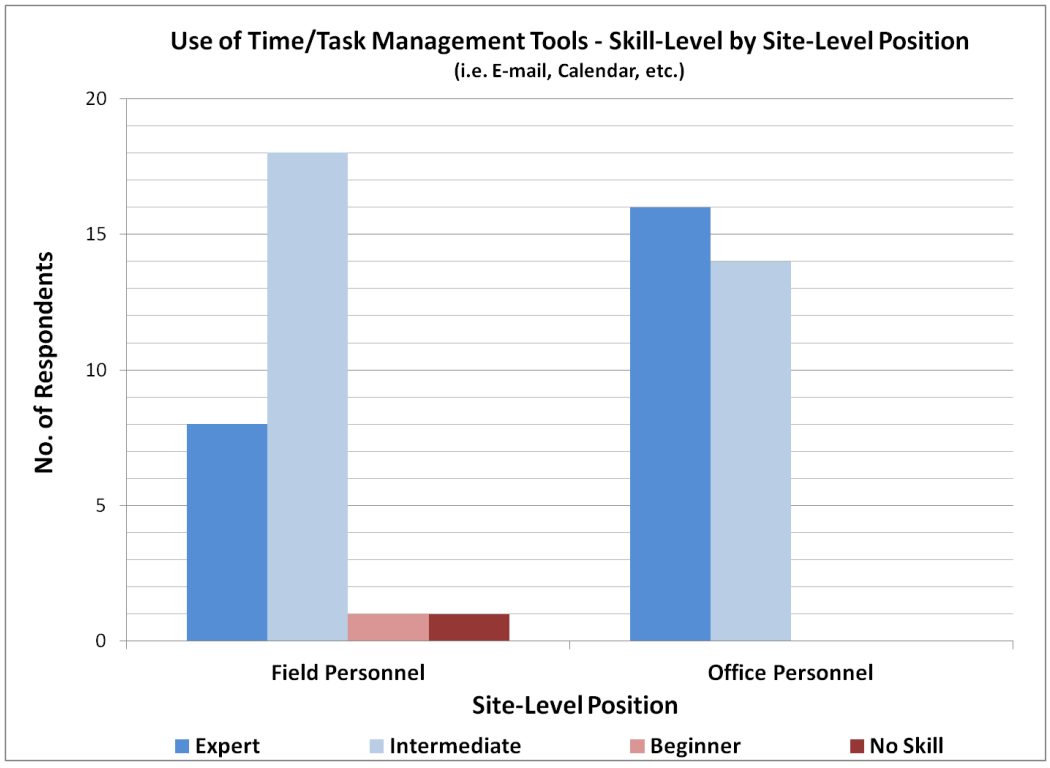

Use of Communication Devices - Skill-Level by Site-Level Position
(i.e. Cell Phones, Radios, etc.)
No. of Respondents
15
10
5
0
Field Personnel
Office Personnel
Site-Level Position
Expert
Intermediate
Beginner
No Skill


Use of Touchscreen Devices - Skill-Level by Site-Level Position
(i.e. Tablets, GPS, iPhones etc.)
No. of Respondents
20
15
10
5
0
Field Personnel
Office Personnel
Site-Level Position
Expert
Intermediate
Beginner
No Skill


Use of Office Documents - Skill-Level by Site-Level Position
(i.e. Presentations, Word Processors, etc.)
No. of Respondents
20
15
10
5
0
Field Personnel
Office Personnel
Site-Level Position
Expert
Intermediate
Beginner
No Skill


Use of Internet Resources - Skill-Level by Site-Level Position
(i.e. Search Engines, Websites, Blogs, etc.)
No. of Respondents
20
15
10
5
0
Field Personnel
Office Personnel
Site-Level Position
Expert
Intermediate
Beginner
No Skill


Use of Electronic Spreadsheets - Skill-Level by Site-Level Position
(i.e. Excel, Calculations, etc.)
20
15
10
5
0
No. of Respondents
Field Personnel
Office Personnel
Site-Level Position
Expert
Intermediate
Beginner
No Skill


Use of Time/Task Management Tools - Skill-Level by Site-Level Position
(i.e. E-mail, Calendar, etc.)
20
15
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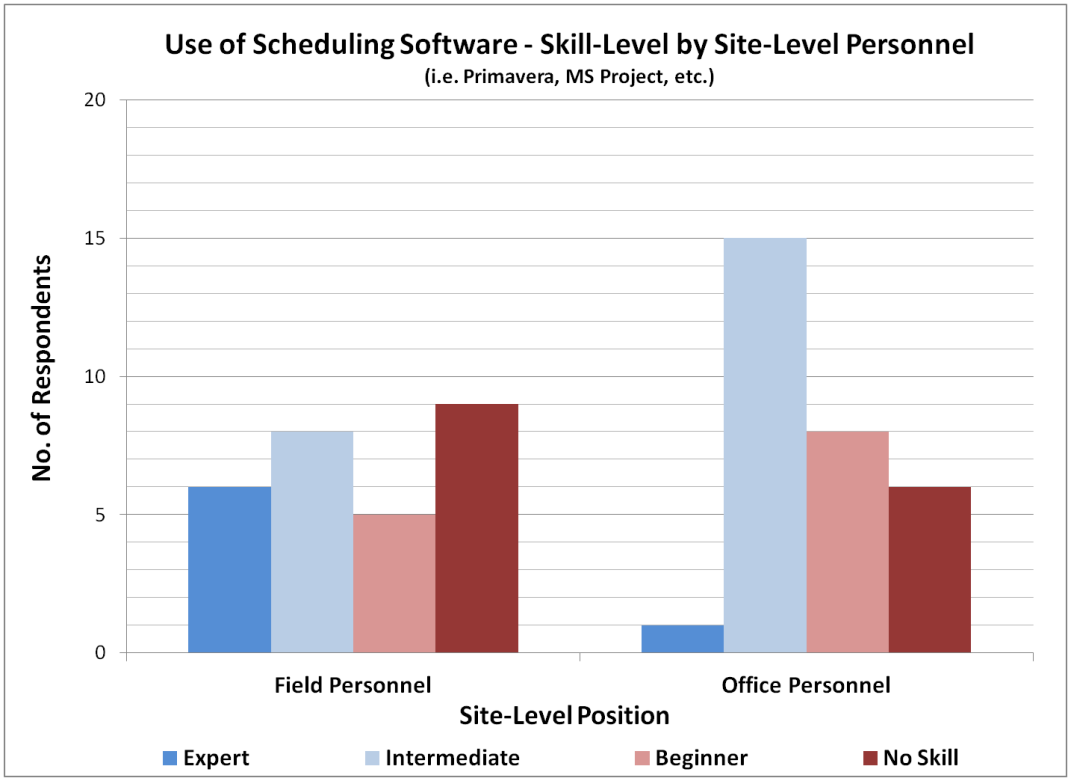
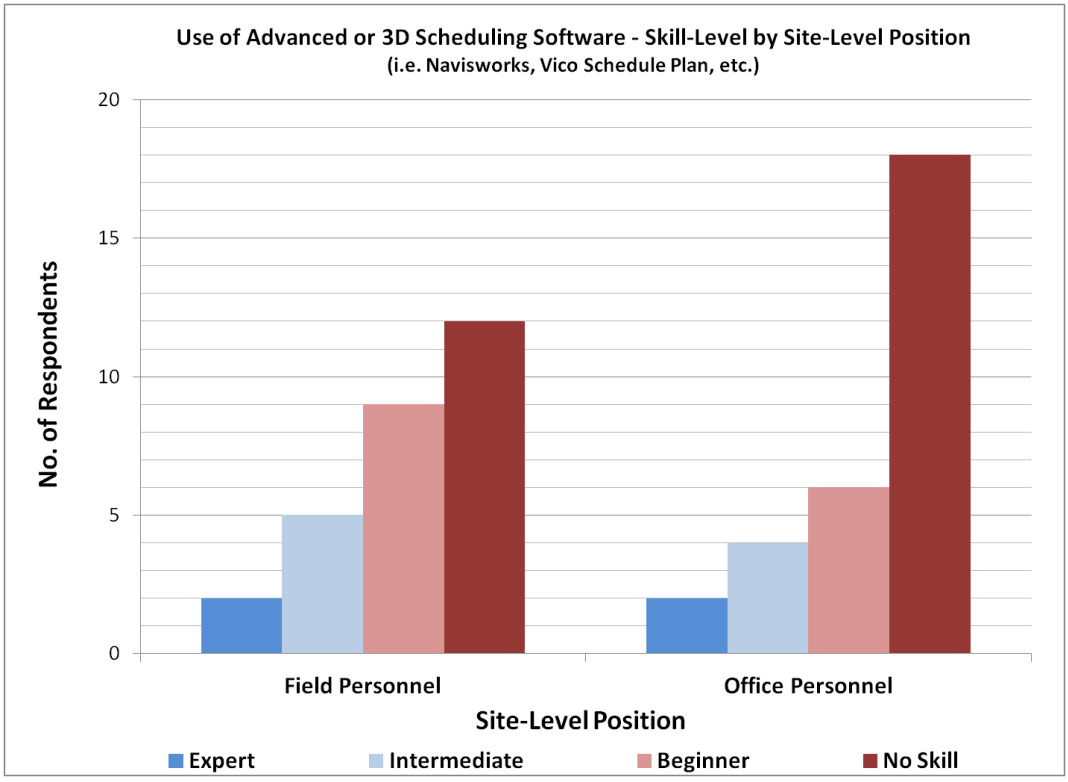
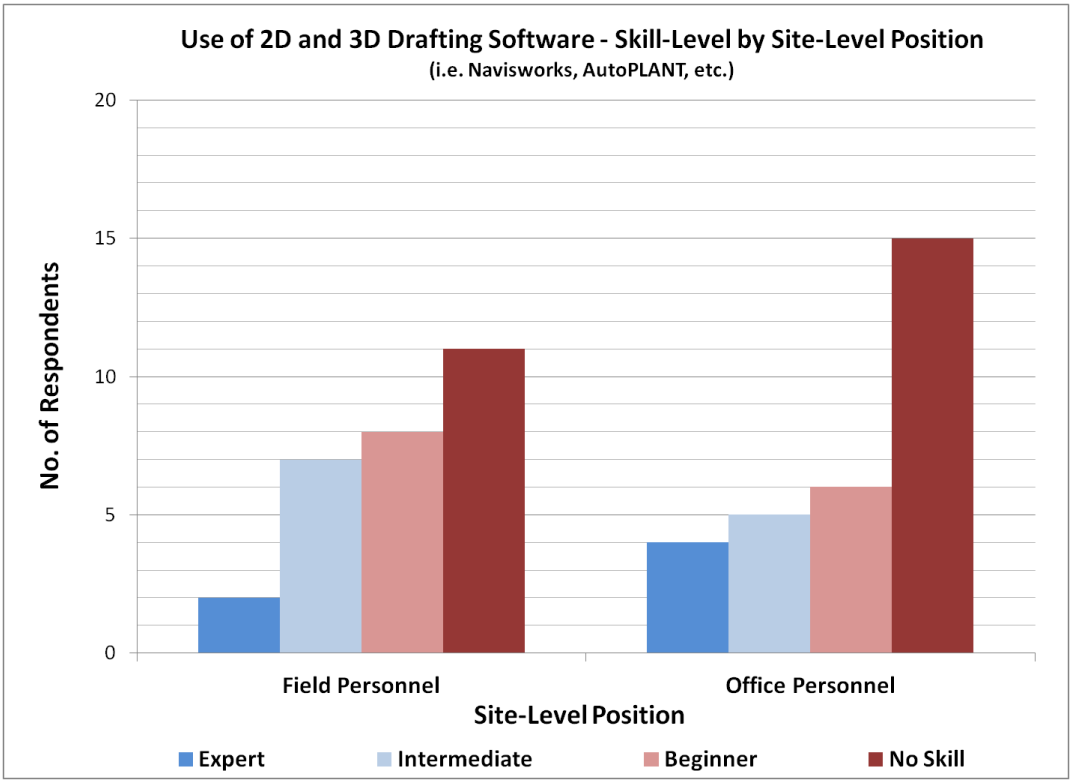
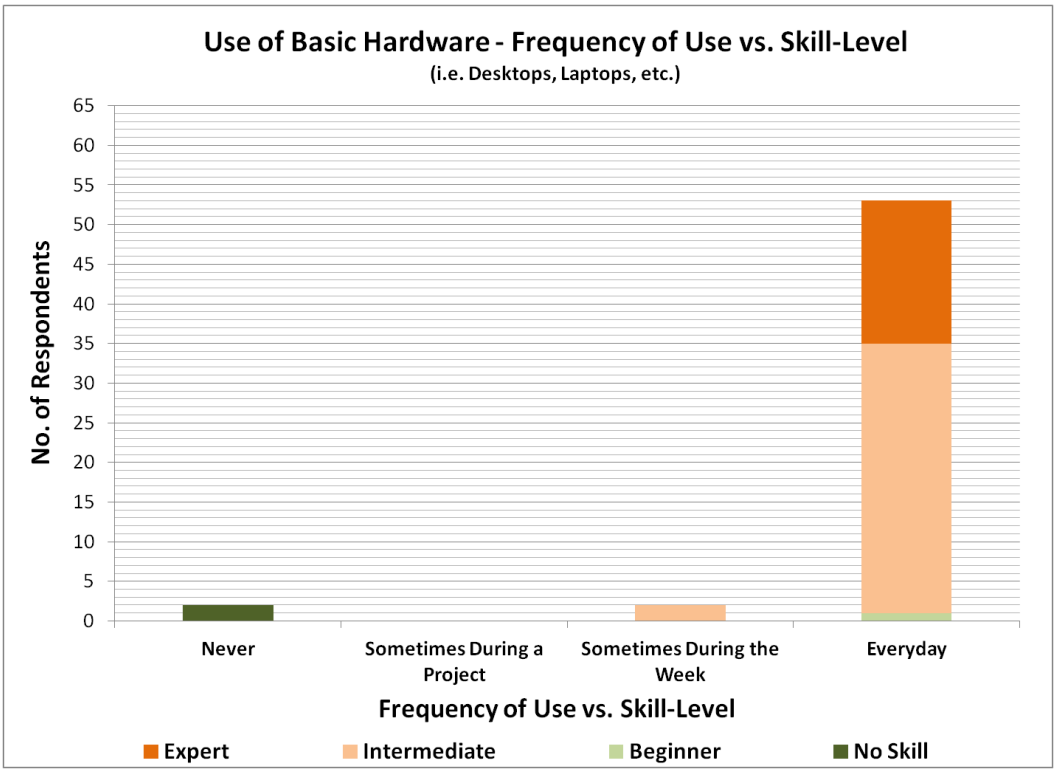
No. of Respondents
Field Personnel
Office Personnel
Site-Level Position
Expert
Intermediate
Beginner
No Skill

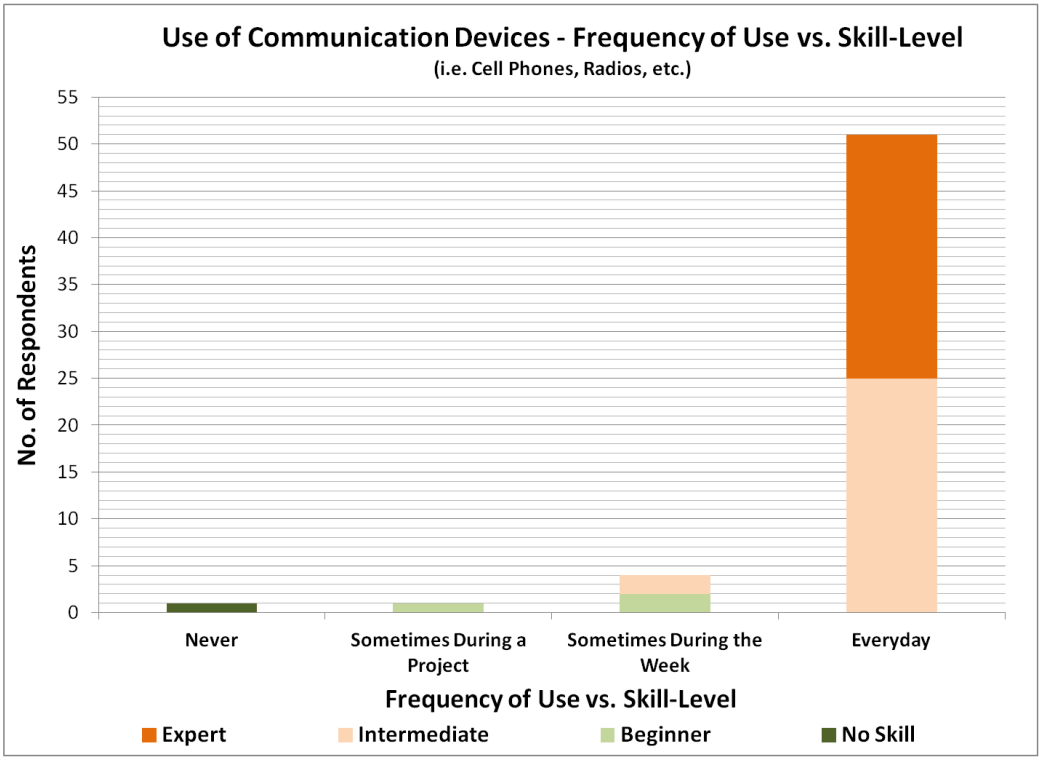

Use of Scheduling Software - Skill-Level by Site-Level Personnel
(i.e. Primavera, MS Project, etc.)
No. of Respondents
20
15
10
5
0
Field Personnel
Office Personnel
Site-Level Position
Expert
Intermediate
Beginner
No Skill

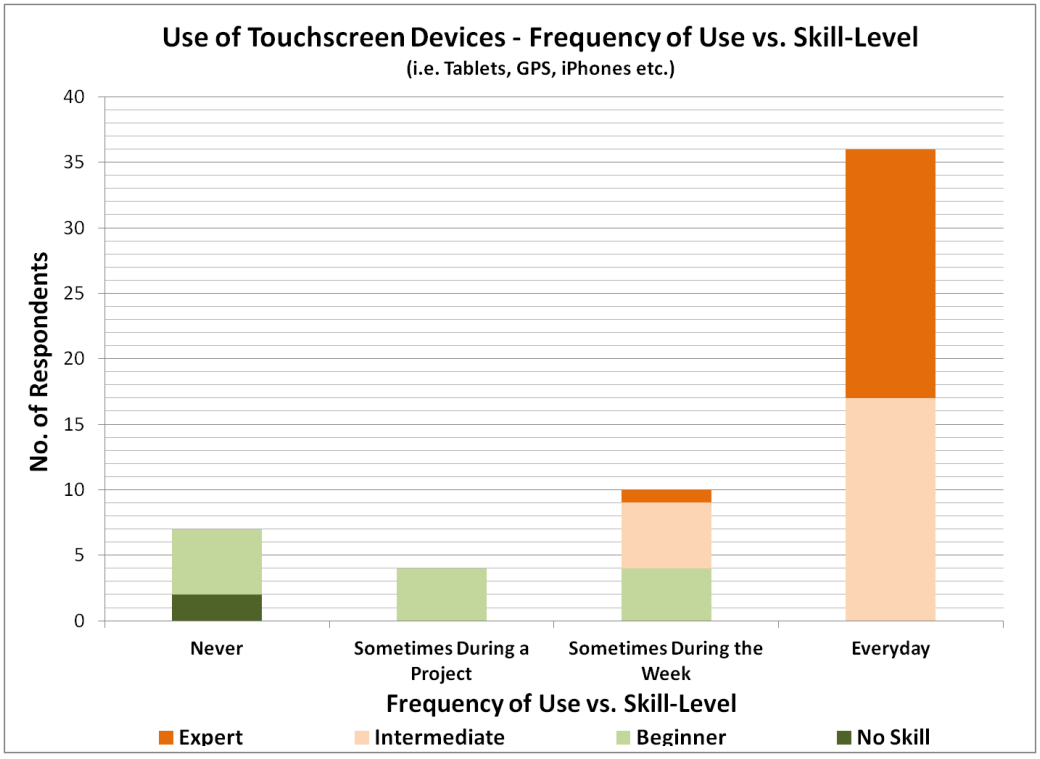

Use of Advanced or 3D Scheduling Software - Skill-Level by Site-Level Position
(i.e. Navisworks, Vico Schedule Plan, etc.)
No. of Respondents
20
15
10
5
0
Field Personnel
Office Personnel
Site-Level Position
Expert
Intermediate
Beginner
No Skill

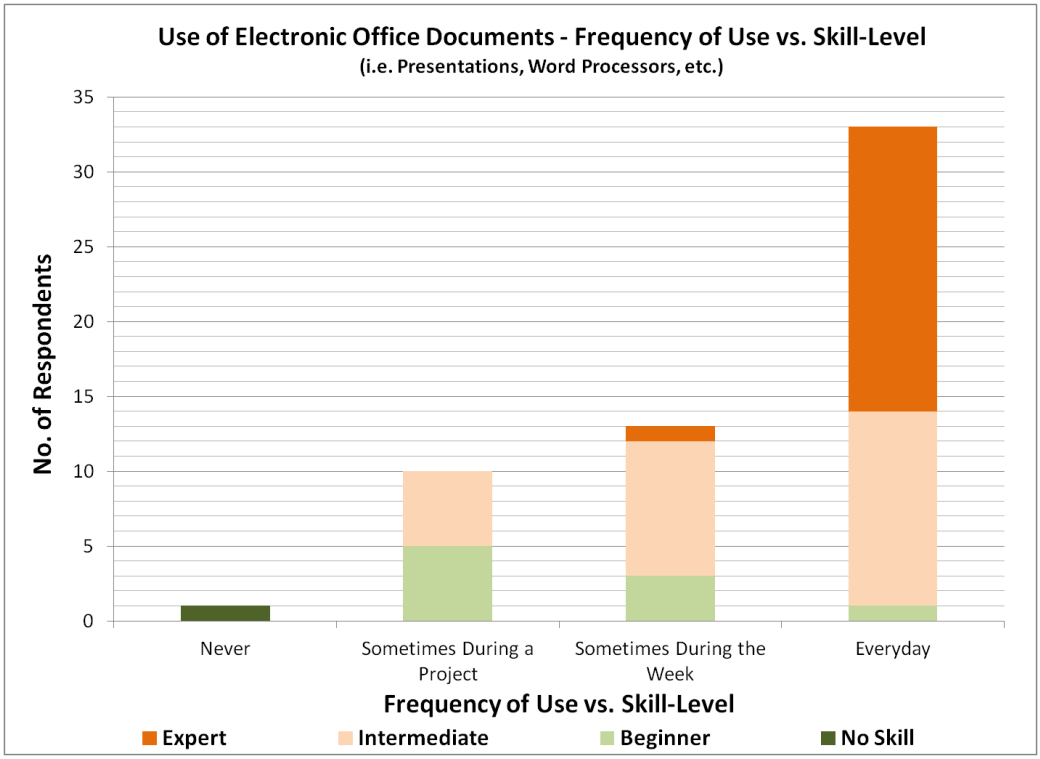

Use of 2D and 3D Drafting Software - Skill-Level by Site-Level Position
(i.e. Navisworks, AutoPLANT, etc.)
No. of Respondents
20
15
10
5
0
Field Personnel
Office Personnel
Site-Level Position
Expert
Intermediate
Beginner
No Skill

A.6 Results - Frequency of Use vs. Skill-Level of IT Tools




Use of Communication Devices - Frequency of Use vs. Skill-Level
(i.e. Cell Phones, Radios, etc.)
No. of Respondents
55
50
45
40
35
30
25
20
15
10
5
0
Never
Sometimes During a Project
Sometimes During the Week
Everyday
Frequency of Use vs. Skill-Level
Expert
Intermediate
Beginner
No Skill


Use of Touchscreen Devices - Frequency of Use vs. Skill-Level
(i.e. Tablets, GPS, iPhones etc.)
No. of Respondents
40
35
30
25
20
15
10
5
0
Never
Sometimes During a Project
Sometimes During the Week
Everyday
Frequency of Use vs. Skill-Level
Expert
Intermediate
Beginner
No Skill


Use of Electronic Office Documents - Frequency of Use vs. Skill-Level
(i.e. Presentations, Word Processors, etc.)
No. of Respondents
35
30
25
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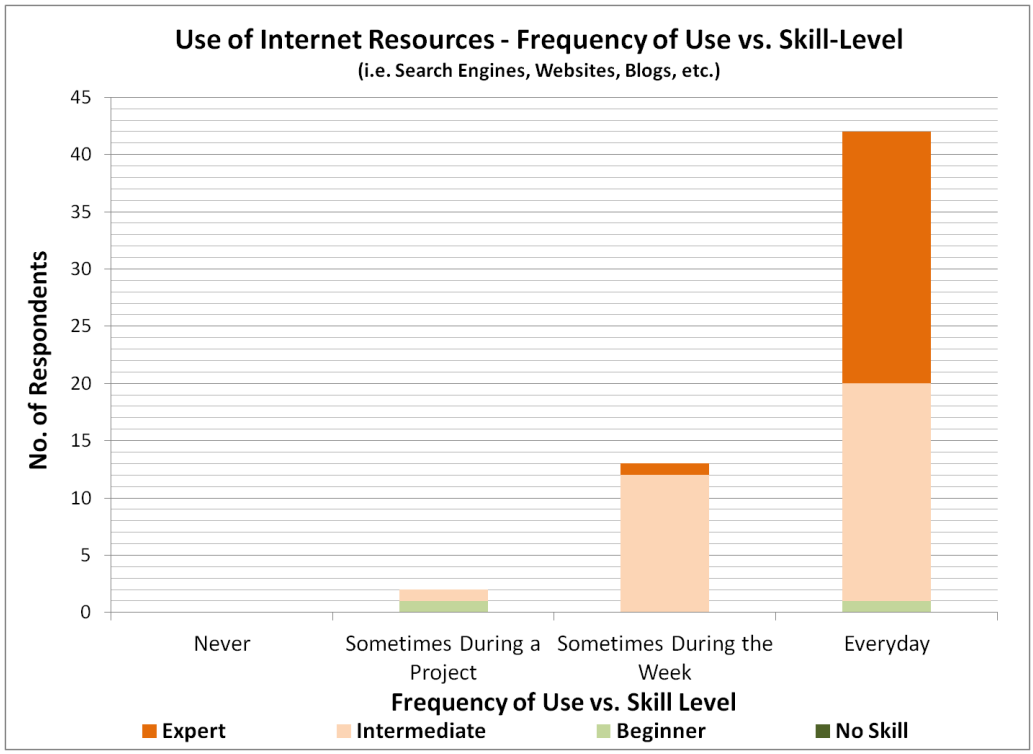
Never
Sometimes During a Project
Sometimes During the Week
Everyday
Frequency of Use vs. Skill-Level
Expert
Intermediate
Beginner
No Skill


Use of Internet Resources - Frequency of Use vs. Skill-Level
(i.e. Search Engines, Websites, Blogs, etc.)
No. of Respondents
45
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35
30
25
20
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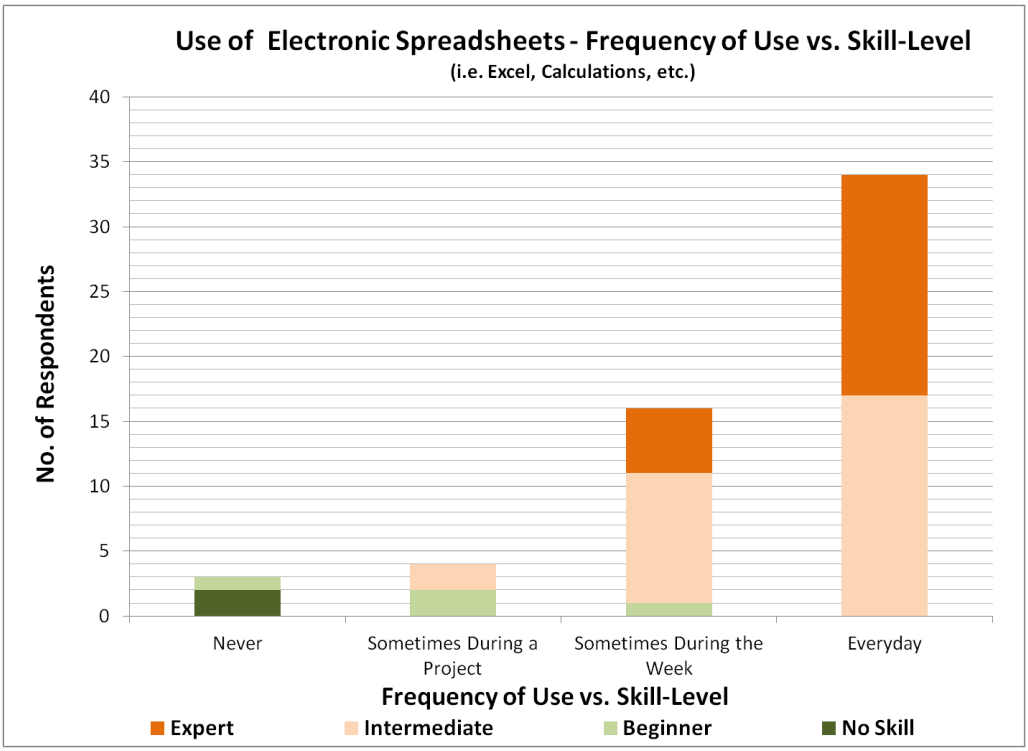
Never
Sometimes During a Project
Sometimes During the Week
Everyday
Frequency of Use vs. Skill Level
Expert
Intermediate
Beginner
No Skill


Use of Electronic Spreadsheets - Frequency of Use vs. Skill-Level
(i.e. Excel, Calculations, etc.)
No. of Respondents
40
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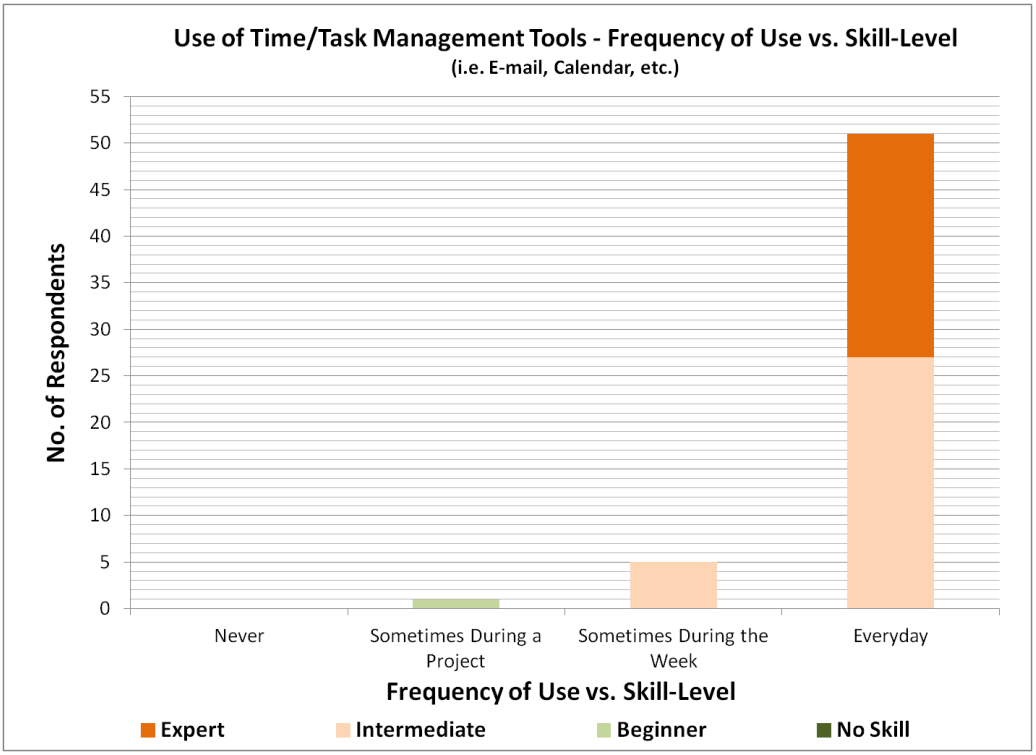
Never
Sometimes During a Project
Sometimes During the Week
Everyday
Frequency of Use vs. Skill-Level
Expert
Intermediate
Beginner
No Skill


Use of Time/Task Management Tools - Frequency of Use vs. Skill-Level
(i.e. E-mail, Calendar, etc.)
No. of Respondents
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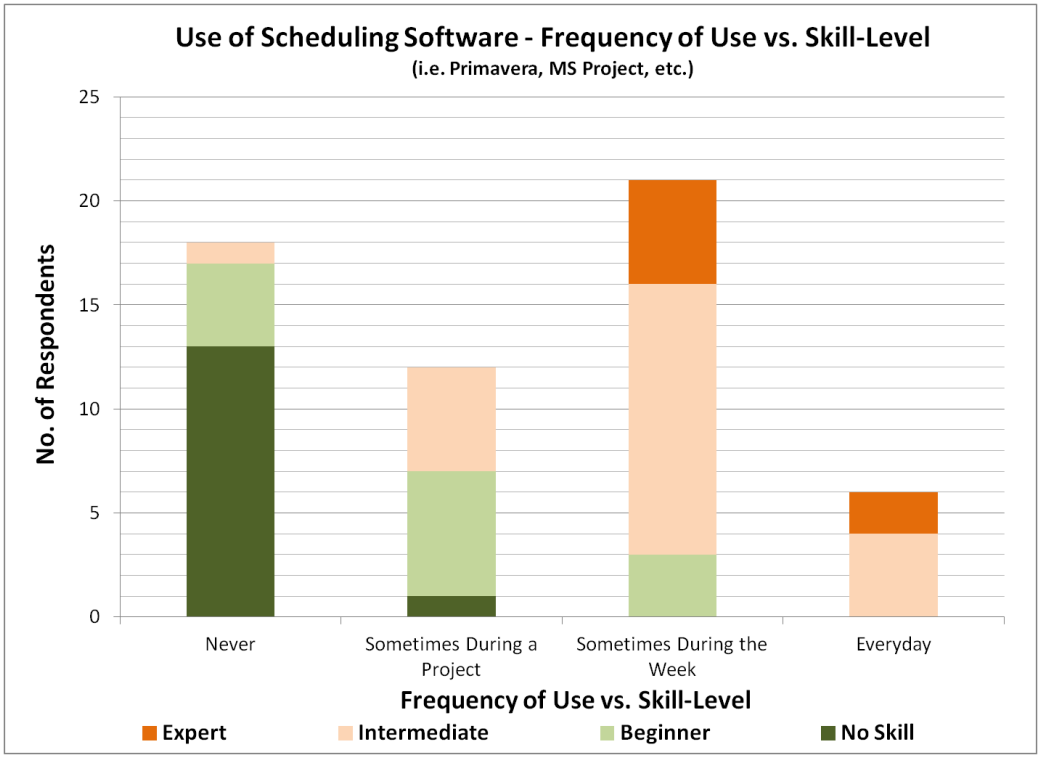
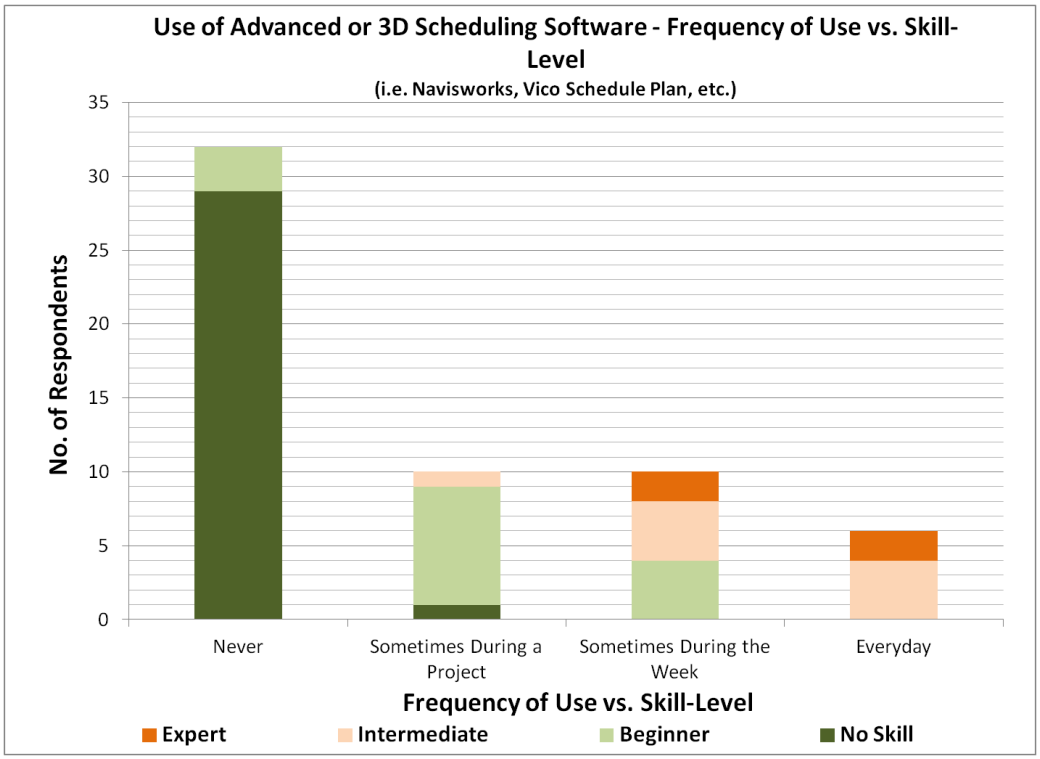
Never
Sometimes During a Project
Sometimes During the Week
Everyday
Frequency of Use vs. Skill-Level
Expert
Intermediate
Beginner
No Skill


Use of Scheduling Software - Frequency of Use vs. Skill-Level
(i.e. Primavera, MS Project, etc.)
No. of Respondents
25
20
15
10
5
0
Never
Sometimes During a Project
Sometimes During the Week
Everyday
Frequency of Use vs. Skill-Level
Expert
Intermediate
Beginner
No Skill


Use of Advanced or 3D Scheduling Software - Frequency of Use vs. Skill-Level
(i.e. Navisworks, Vico Schedule Plan, etc.)
No. of Respondents
35
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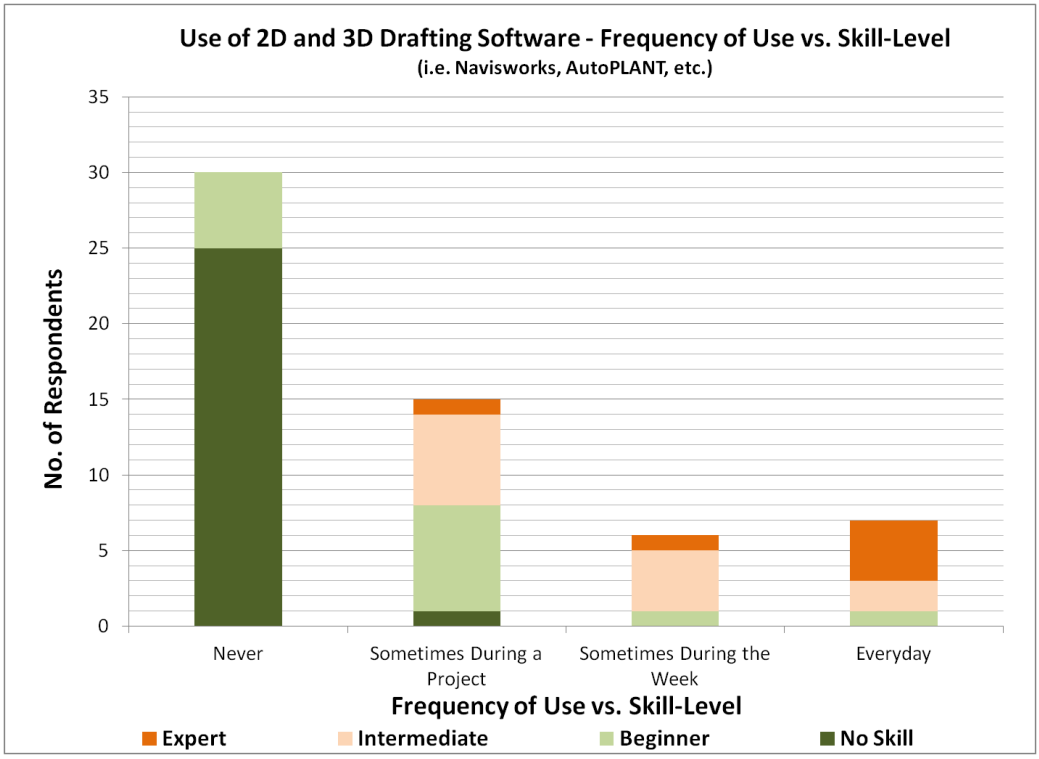
Never
Sometimes During a Project
Sometimes During the Week
Everyday
Frequency of Use vs. Skill-Level
Expert
Intermediate
Beginner
No Skill


Use of 2D and 3D Drafting Software - Frequency of Use vs. Skill-Level
(i.e. Navisworks, AutoPLANT, etc.)
No. of Respondents
35
30
25
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15
10
5
0
Never
Sometimes During a Project
Sometimes During the Week
Everyday
Frequency of Use vs. Skill-Level
Expert
Intermediate
Beginner
No Skill

Appendix B: Follow-Up Interview for Field Personnel

B.1 Interview Questionnaire (Blank Form)

General Scenario:

- Average project in the middle of construction.
- Either Lump Sum or Supervising Sub-contracted work hard bid

1. Provided the general scenario:
    a. In which instances would you engage the process of collecting onsite information and developing documents?

    b. In which instances would you pull that information back for your use? – Specific meetings, inspections

    c. In the survey, you responded that you are (how likely? – reference survey) to take these documents for meetings and inspections. To elaborate on your response, please tell us if you carry around the documents for personal reference/as reference during meetings /as meeting handouts/or distribution?

    d. Which work documents would you produce in typical week?

    e. Are these documents provided by your firm, developed by yourself?

2. To what extent do you utilize the software mentioned in the survey (ref survey) to collect and distribute information for these work documents?

3. Are these information technologies being utilized in conjunction with HHC's/Mobile Devices, 3-D Modeling, Misc Info Focal Points (email, Share Drives, BIM), Software, etc.?

4. When does the use of the software mentioned help you? (i.e. provide specific information, time benefits, facilitate process, distribute information, etc.) Please mention particular functions that aid your onsite decisions, including meetings and inspections.

5. When does software get in the way? (i.e. difficult to understand/communicate, time consuming, inadequate results, unable to share information, etc.). Please mention particular functions that are inadequate for your purposes.

6. Based on your current methods (i.e. paper-based, HHC, etc.), what information do you find the most difficult to collect, maintain, and organize onsite?

7. Does your current process of developing documents (1d) facilitate communication between stakeholders and allow you to make adequate onsite decisions? Could you provide an example?

8. Do you feel your company could improve the following construction activities/processes with the use of better software or information technologies? (Reference survey, which software they use)

Design/Specs: Yes No

If yes, how? With what technologies?

If no, are you aware of any beneficial technologies associated with this activity?

Material Management: Yes No

If yes, how? With what technologies?

If no, are you aware of any beneficial technologies associated with this activity?

Project Controls: Yes No

If yes, how? With what technologies?

If no, are you aware of any beneficial technologies associated with this activity?

Quality Control: Yes No

If yes, how? With what technologies?

If no, are you aware of any beneficial technologies associated with this activity?

Safety: Yes No

If yes, how? With what technologies?

If no, are you aware of any beneficial technologies associated with this activity?

Project Delivery: Yes No

If yes, how? With what technologies?

If no, are you aware of any beneficial technologies associated with this activity?

B.2 Interview Respondents - Summary List

Assigned Company Letter	Assigned Interview No. Per Company	Job Title	Industry Sector	Worksite Location
A	1	Field Engineer	Infastructure	Spingfield, MA
B	1	Area Superintendent	Commercial	Austin, TX
B	2	Project Superintendent	Commercial	Austin, TX
B	3	Area Superintendent	Commercial	Austin, TX
B	4	Project Superintendent	Commercial	Austin, TX
B	5	Project Superintendent	Commercial	Austin, TX
B	6	Project Superintendent	Commercial	Austin, TX
B	7	Area Superintendent	Commercial	Austin, TX
C	1	Technical Services Specialist	Industrial	Houston, TX
C	2	Field Engineer	Industrial	Houston, TX
C	3	Piping Activity Planner	Industrial	Houston, TX
C	4	Project Superintendent	Industrial	Houston, TX
C	5	Civil Superintendent	Industrial	Houston, TX
C	6	Pipe General Foreman	Industrial	Houston, TX
C	7	Controls General Foreman	Industrial	Houston, TX
C	8	Civil General Foreman	Industrial	Houston, TX
C	9	Electrical Superintendent	Industrial	Houston, TX
D	1	Structural Superintendent	Industrial	Houston, TX
D	2	Civil Superintendent	Industrial	Houston, TX
D	3	Foreman	Industrial	Houston, TX
D	4	Piping Superintendent	Industrial	Houston, TX

B.3 Interview Responses - Raw Data

Company A - Interview 1

Position: Field Engineer
Industry Experience: 2 years

1. Provided the general scenario:
    a. In which instances would you engage in this process? – Collect information, develop documents
        - Daily Inspections
        - Creation of Daily Report's, Quantity Take-Off's, Site Inspection Reports, Quality Control (taking pictures) in conjunction with Specs and Plans

    b. In which instances would you pull that information back for your use? – Specific meetings, inspections
        - Checking invoices (Ref 1c)
        - Rarely have meetings with the contractor

    c. In the survey, you responded that you are (how likely? – reference survey) to take these documents for meetings and inspections. To elaborate on your response, please tell us if you carry around the documents for personal reference/as reference during meetings /as meeting handouts/or distribution?
        - Not applicable, does not typically participate in meetings, also does not typically need to reference back to created documentation. Company has very "Old School" way of doing things. The collected daily documentation/information is used at the end of the month as back-up for pay requisitions. The daily documentation is recorded on a computer at the end of the month for pay requisitions and then hardcopies of the pay requisitions are distributed to associated parties for sign off.

    d. Which work documents would you produce in typical week?
        - **Daily reports** - hand written; based on project info performed every day - weather, police officers, quantity take offs etc.
        - **Quantity take-off Sheets** - hand written; info taken from daily reports
        - **Quality Control** - Take pictures; later upload on a computer at the main office, saved by date
        - **Collection of Info/Distribution of Plans and Specs** - Done with Adobe; don't typically mark up plans, when they do mark up hard copies, done with red pen in the field.

- No documentation/paper work goes into the computer until they do their monthly invoices.

e. Are these documents provided by your firm, developed by yourself?
   - City of Springfield Engineering department developed the documents.

2. To what extent do you utilize the software mentioned in the survey (ref survey) to
   a. collect and
      - Do not use any software to collect information in the field
   b. distribute information for these work documents?
      - Collect information on to an electronic document at the end of the month for pay requisition and then distribute hard copies to associated parties.

3. Are these information technologies being utilized in conjunction with HHC's/Mobile Devices, 3-D Modeling, Misc Info Focal Points (email, Share Drives, BIM), Software, etc.?
   - Don't have mobile devices or misc focal points.

4. When does the use of the software mentioned help you? (i.e. provide specific information, time benefits, facilitate process, distribute information, etc.) Please mention particular functions that aid your onsite decisions, including meetings and inspections.
   - Not applicable

5. When does it get in the way? (i.e. difficult to understand/communicate, time consuming, inadequate results, unable to share information, etc.). Please mention particular functions that are inadequate for your purposes.
   - Not applicable

6. Does your current process of developing documents (1d) facilitate communication between stakeholders and allow you to make adequate onsite decisions? Could you provide an example?
   - Only for own use, the contractor never sees documentation. On-site decision based on "Standard Specification for Highways and Bridges" and Blue Books (Specs) along with city specs and what the plans say.

7. Do you feel your company could improve the following construction activities/processes with the use of better software or information technologies? (Reference survey, which software they use)

Design/Specs: ***Yes*** No

If yes, how? With what technologies?

- No additional information provided

If no, are you aware of any beneficial technologies associated with this activity?

Project Controls: ***Yes*** No

If yes, how? With what technologies?

- Utilize online database or share drive that the client or consultant could reference for on-site information. Or an online data base the public has reference to for online chats and discussions.

If no, are you aware of any beneficial technologies associated with this activity?

Quality Control: ***Yes*** No

If yes, how? With what technologies?

- Application - take a picture of item, records GPS coordinates, and description. Sends information to a database at the home office. Suggested Technology: "Cartegraph" - Utilized for 2011 tornado clean up.

If no, are you aware of any beneficial technologies associated with this activity?

Company B - Interview 1

Position: Area Superintendent
Experience: 32 years in industry, 10 Years as Area Superintendent

1. Provided the general scenario:
    a. In which instances would you engage in this process? – Collect information, develop documents
        - Subcontractors' coordination, reporting progress to owner, field supervision

    b. In which instances would you pull that information back for your use? – Specific meetings, inspections
        - Subs meetings, field inspections – progress, safety, punchlisting, schedule tracking

    c. In the survey, you responded that you are Very Likely to take these documents for meetings and inspections. To elaborate on your response, please tell us if you carry around the documents for personal reference/as reference during meetings /as meeting handouts/or distribution?
        - Very likely to carry documents. For personal reference, and also as a reference for subcontractors.

    d. Which work documents would you produce in typical week?
        - 4wk look ahead, once a week; SAFE reports, 6-10 a week

    e. Are these documents provided by your firm, developed by yourself?
        - Schedules and spreadsheets sometimes developed by himself, sometimes company templates. SAFE reports are strictly the company's template.
        - The content of these documents responds to the needs to communicate with subcontractors

2. To what extent do you utilize the software mentioned in the survey (ref survey) to
    a. collect and
    b. distribute information for these work documents?
    - Uses spreadsheets in electronic format on his phone every day to collect information in the field or update back in the office. Also converts his own documents to PDF for viewing in the field.

    - Presents printed schedule to subcontractors during meetings, but may show them the electronic document in the field.

- Printouts from Prolog for subcontractors (including RFIs, change orders)

3. Are these information technologies being utilized in conjunction with HHC's/Mobile Devices, 3-D Modeling, Misc Info Focal Points (email, Share Drives, BIM), Software, etc.?
    - Use phone (both Android and iOS devices) to access his own spreadsheets.
    - Uses iPad and iPhone for SAFE reports in the field.
    - Uses iPhone for emails in the field.

4. When does the use of the software mentioned help you? (i.e. provide specific information, time benefits, facilitate process, distribute information, etc.) Please mention particular functions that aid your onsite decisions, including meetings and inspections.
    - iPhone is preferred for SAFE reports for collecting information. (Not necessarily related to SAFE reports) It allows to make phone calls as soon as something comes up in the field.
    - Using own PDFs and spreadsheets to access schedule in the field.
    - Use of Prolog allows him to look into RFIs. In general doesn't mind doing paperwork in Prolog.
    - Use of phone /voice notes for himself. Access notes in the office to update schedule or punchlists.

5. When does it get in the way? (i.e. difficult to understand/communicate, time consuming, inadequate results, unable to share information, etc.). Please mention particular functions that are inadequate for your purposes.
    - iPads can be clunky to carry, iPhones are more adequate.

    - When the schedule is too sophisticated it does not really help to communicate with subcontractors. For example, the project schedule is developed in Primavera P6, but it really is not useful to communicate with subs as much as the look-ahead developed plainly in Excel. Was sometimes time-consuming.

6. Based on your current methods (i.e. paper-based, HHC, etc.), what information do you find the most difficult to collect, maintain, and organize onsite?
    - Accessing and edit drawings in the field--PDF editor (Question 8 "Design/Specs")

    - Accessing and organizing Project Controls info -- would be easier with the use of iPad to access Prolog in the field

7. Does your current process of developing documents (1d) facilitate communication between stakeholders and allow you to make adequate onsite decisions? Could you provide an example?

- Yes. On a "normal job", 1 subs meeting per week is adequate and, if things start running late, they can be met in the field. So, one set of documents for the meetings is enough: updating the 4wk look-ahead once a week, and the project schedule once a month is usually enough.

8. Do you feel your company could improve the following construction activities/processes with the use of better software or information technologies? (Reference survey, which software they use)

Design/Specs: ***Yes*** No
If yes, how? With what technologies?
- Yes for larger projects, use iPads to access drawings in the field
- PDF editors that can actually do something

If no, are you aware of any beneficial technologies associated with this activity?

Material Management: ***Yes*** No
If yes, how? With what technologies?
- iPad. No further comments, just that it would be helpful to access material information in the field.

If no, are you aware of any beneficial technologies associated with this activity?

Project Controls: ***Yes*** No
If yes, how? With what technologies?
- Use of Prolog in the field

If no, are you aware of any beneficial technologies associated with this activity?

Quality Control: ***Yes*** No
If yes, how? With what technologies?
iPad. No further comments, just that it would be helpful to access QC inspections information in the field.
If no, are you aware of any beneficial technologies associated with this activity?

Safety: Yes ***No***
If yes, how? With what technologies?
SAFE. already works well.

If no, are you aware of any beneficial technologies associated with this activity?

Project Delivery: ***Yes*** No
If yes, how? With what technologies?

If no, are you aware of any beneficial technologies associated with this activity?

- Excel works out fine as opposed to other software that the "interviewee" has tested. States that he has closed out projects with up to 17,000 items in the punchlist without losing a single one; using Excel.

Company B - Interview 2

Position: Project Superintendent
Industry Experience: 25 Years w/ current company, 15 Years as a Superintendent

1. Provided the general scenario:
    a. In which instances would you engage in this process? – Collect information, develop documents
        - Team coordination, reporting progress to owner, field supervision

    b. In which instances would you pull that information back for your use? – Specific meetings, inspections
        - Weekly Owners Meetings, Onsite Inspections, Subcontractor Meetings (for area superintendents)
        - Develop 6 Part Folder: Life Cycle of Subcontractors - Contractual Documentation, Specs, Drawings, Premob Meetings, Prep Meetings, Initial and Follow-up Meetings

    c. In the survey, you responded that you are (how likely? – reference survey) to take these documents for meetings and inspections. To elaborate on your response, please tell us if you carry around the documents for personal reference/as reference during meetings /as meeting handouts/or distribution?
        - Very likely to carry documents. For instance the premob meetings, prep meetings, initial and follow-up meeting documentation, bring SAFE dashboard into morning meetings

    d. Which work documents would you produce in typical week?
        - Daily Reports, Man Power Charts and Trends - w/ use of Prolog
        - Some agendas and drawings by hand, SAFE report cards with SAFE system, owner's meeting agenda with Prolog

    e. Are these documents provided by your firm, developed by yourself?
        - Typically, utilize standardized documents
        - Company templates

2. To what extent do you utilize the software mentioned in the survey (ref survey) to
    a. collect and
    b. distribute information for these work documents?
    - Prepare meeting notes, plans, etc. Prepared in the office. Hardcopies brought into the field.
    - Daily Reports, Man Power Charts and Trends - w/ use of Prolog

3. Are these information technologies being utilized in conjunction with HHC's/Mobile Devices, 3-D Modeling, Misc Info Focal Points (email, Share Drives, BIM), Software, etc.?
    - Currently, only the Safety Team is utilizing IPads in conjunction S.A.F.E. software (company software) . Safety Team will be onsite for 4-6 hrs per day collecting data on safety concerns and mishaps, and occurrences. Team will then develop data creating pie charts/trends for "tool box" meetings in the morning to help the project team identify where and when the majority of the safety issues are occurring.

    - Interviewee anticipates the "6 Part Folder: Life Cycle of Subcontractors" document being transferred to an electronic type document. Stated this is being done on project sites in California and has been very useful. Interviewee also anticipates this very beneficially for his projects.

4. When does the use of the software mentioned help you? (i.e. provide specific information, time benefits, facilitate process, distribute information, etc.) Please mention particular functions that aid your onsite decisions, including meetings and inspections.
    - Reference Answer to Question #3.
    - Use of P6 to produce 90-day schedules out of the less detailed Project Schedule takes more time up front to develop but it’s more beneficial throughout the project.

5. When does it get in the way? (i.e. difficult to understand/communicate, time consuming, inadequate results, unable to share information, etc.). Please mention particular functions that are inadequate for your purposes.
    - Transition of Prolog Information - recently. Transferred, Prolog data from CRAM group (consultant group managing Hensel Phelps data center) to Hensel Phelps servers. Didn't have appropriate Windows interface to access to Prolog documentation. Server issue, not Prolog issue.
    - Also, found that too much access or use of multiple devices simultaneously can cause delays/distractions. However, stated he would rather have too much access than no access at all.
    - Use of SAFE app on iPhone is difficult, screen too small to read adequately what is being typed.

6. Based on your current methods (i.e. paper-based, HHC, etc.), what information do you find the most difficult to collect, maintain, and organize onsite?
    - Some agendas and drawings by hand.-- other individuals will go out to the field and take data from "interviewee" to develop documents in the office on the computer, including, alterations to specs, plans, and RAD (Risk Assessment Data) data base

- Producing Daily Reports in the field -- rather do in the office.
    - Concerned with utilizing Prolog in the field for Project Controls (i.e. daily reports), typically done back at the office. Although it would be a significant time saver and easier to perform in the field it may affect the overall quality of the report. Considering it is technically a legal document and the "owner" and PM have real-time access to this information you must be careful what is written and documented. The field environment may not be optimal for this
- Managing the "6 Part Folder: Life Cycle of Subcontractors".

7. Does your current process of developing documents (1d) facilitate communication between stakeholders and allow you to make adequate onsite decisions? Could you provide an example?
    - Yes. In the past, each project would take a generic document and fine-tune it to meet their particular project needs. However, now, they have been moving towards standardized documents which has been very helpful. Standardization is also necessary, when it comes to documents for meetings and etc.
    - In some instances, when available, other individuals will go out to the field and take data from "interviewee" to develop documents in the office on the computer, including, alterations to specs, plans, and RAD (Risk Assessment Data) data base.
    - Utilizes his own "hardcopy" information in the field. Will also mark up, or "cloud", documents in the field or at the field office referencing changes made in the field. Will utilize clouded plans to reference associated RFI information.
    - Almost too many documents on site. Important to know which documents are necessary for a meeting to avoid spending too much time deciding on it. Make use of document database.

8. Do you feel your company could improve the following construction activities/processes with the use of better software or information technologies? (Reference survey, which software they use)

    Design/Specs: ***Yes*** No
    If yes, how? With what technologies?
    - Would be a huge benefit to have daily updated plans, specs, etc on the IPad in the field.
    - Having plans updated “overnight”

    If no, are you aware of any beneficial technologies associated with this activity?
    - No specific associated technology mentioned.

    Material Management: Yes ***No***

If yes, how? With what technologies?

- Current use of Prolog in regard to Material Management is very beneficial, however the use of this technology in the field would not be as helpful. This process is more of an office engineers responsibility. A software would only be useful in the field if it had standardized functionalities for specific materials (example used: standard air handler type functionality)

If no, are you aware of any beneficial technologies associated with this activity?

Project Controls: ***Yes*** No

If yes, how? With what technologies?

- The use of Primavera scheduler in conjunction with an IPad could be beneficial if there was a specific functionality that allowed the user to input progress and % of activities completed. This information could be electronically delivered to the office everyday for schedule updates. Also, if there were a type of "pop-up" functionality that notified users of completion dates and delay alerts -- subcontractors behind on work.
- Also, concerned with utilizing Prolog in the field for Project Controls (i.e. daily reports), typically done back at the office. Although it would be a significant time saver and easier to perform in the field it may affect the overall quality of the report. Considering it is technically a legal document and the "owner" and PM have real-time access to this information you must be careful what is written and documented. The field environment may not be optimal for this.

If no, are you aware of any beneficial technologies associated with this activity?

Quality Control: ***Yes*** No

If yes, how? With what technologies?

- The use of IPad's in conjunction with a software that provided an inspection form and dropdown menus. Would prefer an area where you could physically write in or voice-in miscellaneous data and notes instead of typing, which may prove to be distracting and time consuming. Indicated would be beneficial to be able to attach pictures directly to the form.

If no, are you aware of any beneficial technologies associated with this activity?

Safety: ***Yes*** No

If yes, how? With what technologies?

- In house program S.A.F.E. already works well. Used in conjunction with IPad.

If no, are you aware of any beneficial technologies associated with this activity?

Project Delivery: ***Yes*** No

If yes, how? With what technologies?

- May be useful for punch listing items to have infield access. Would need to create standardized electronic documents and forms to make this work properly.

If no, are you aware of any beneficial technologies associated with this activity?

Company B – Interview 3

Position: Area Superintendent
Industry Experience: 24 Years w/ current company, 8 Years as Area Superintendent
30 years in industry

1. Provided the general scenario:
    a. In which instances would you engage in this process? – Collect information, develop documents
        - Subcontractors' coordination, field supervision, safety supervision

    b. In which instances would you pull that information back for your use? – Specific meetings, inspections
        - Subs meetings, field inspections – progress, safety, punchlisting, schedule tracking

    c. In the survey, you responded that you are Likely to take these documents for meetings and inspections. To elaborate on your response, please tell us if you carry around the documents for personal reference/as reference during meetings /as meeting handouts/or distribution?
        - For personal reference, and also as a reference for subcontractors.
        - Walk with Schedule for field supervision, once a week.
        - SAFE reports in the field.
        - Subcontractors meeting pkg (including 4wk look-ahead ,agenda, some daily logs, RFI log, CO log) for communication
        - Take red folders with product data for materials, to make sure materials that are being delivered or installed are correct.

    d. Which work documents would you produce in typical week?
        - 4wk look ahead in Excel, once a week; SAFE reports, 6-10 a week; daily logs, every day.

    e. Are these documents provided by your firm, developed by yourself?
        - Mostly provided by the firm.
        - The Subs Meeting Agenda is developed by himself.

2. To what extent do you utilize the software mentioned in the survey (ref survey) to
    a. collect and
    b. distribute information for these work documents?
        - Use of Prolog, in the office, for collecting daily reports info, print out RFI or CO logs for distribution to subs; Excel for collecting schedule info, trend charts info (he doesn't develop these, but he uses them); SAFE for

collection and real-time distribution safety reports; Adobe Acrobat for viewing drawings.

3. Are these information technologies being utilized in conjunction with HHC's/Mobile Devices, 3-D Modeling, Misc Info Focal Points (email, Share Drives, BIM), Software, etc.?
    - Uses iPad and iPhone for SAFE reports in the field. Prefers iPad because of screen size
    - Uses iPhone for checking emails in the field, particularly for checking RFI items. Also uses iPhone in the field for requesting details from the office, taking pictures. He reckons that saves time from going back and forth to the field.

4. When does the use of the software mentioned help you? (i.e. provide specific information, time benefits, facilitate process, distribute information, etc.) Please mention particular functions that aid your onsite decisions, including meetings and inspections.
    - SAFE is very useful for keeping track of the subs, particular workers and time of safety hazards detected.
    - Uses email for documentation, which is better than phone conversations since you have things written.
    - Can check RFI items (via e-mail) in real-time, and talk to subcontractors about starting on that piece of work as soon as RFIs are approved.

5. When does it get in the way? (i.e. difficult to understand/communicate, time consuming, inadequate results, unable to share information, etc.). Please mention particular functions that are inadequate for your purposes.
    - Prolog was down so it was necessary to wait on some answers. However, this type of problem can be solved using the phone, knowing who to contact.

6. Based on your current methods (i.e. paper-based, HHC, etc.), what information do you find the most difficult to collect, maintain, and organize onsite?
    - Punchlist -could be done faster with an Ipad in the field
    - Access to Specs and Red Folder in the field

7. Does your current process of developing documents (1d) facilitate communication between stakeholders and allow you to make adequate onsite decisions? Could you provide an example?
    - Perhaps improving use of the calendar, input more dates and times of inspections.

8. Do you feel your company could improve the following construction activities/processes with the use of better software or information technologies? (Reference survey, which software they use)

Design/Specs: ***Yes*** No
If yes, how? With what technologies?

- Use iPads to access drawings. Currently, he may use his iPhone for this purpose

If no, are you aware of any beneficial technologies associated with this activity?

Material Management: ***Yes*** No
If yes, how? With what technologies?

- Having access to google, MSDS, clarifications

If no, are you aware of any beneficial technologies associated with this activity?

Project Controls: Yes ***No***
If yes, how? With what technologies?

If no, are you aware of any beneficial technologies associated with this activity?

Quality Control: ***Yes*** No
If yes, how? With what technologies?

- Having access to specs/red folder in the field

If no, are you aware of any beneficial technologies associated with this activity?

Safety: Yes ***No***
If yes, how? With what technologies?

- SAFE. already works well.

If no, are you aware of any beneficial technologies associated with this activity?

Project Delivery: ***Yes*** No
If yes, how? With what technologies?

- iPad with punchlist could make the process faster in the field.

If no, are you aware of any beneficial technologies associated with this activity?

Company B – Interview 4

Position: Project Superintendent
Industry Experience: 20 yrs in Construction, 12 yrs at current company

1. Provided the general scenario:
    a. In which instances would you engage in this process? – Collect information, develop documents
        - N/A

    b. In which instances would you pull that information back for your use? – Specific meetings, inspections
        - Meetings
        - Inspections
        - Utilizes hardcopies of the schedule in the field to mark-up and update schedule, then brings back to the office to officially update schedule.
        - Utilizes Prolog Database to compile submittals, RFI's, QC Logs for meetings.
        - QC inspections; subs meetings

    c. In the survey, you responded that you are (how likely? – reference survey) to take these documents for meetings and inspections. To elaborate on your response, please tell us if you carry around the documents for personal reference/as reference during meetings /as meeting handouts/or distribution?
        - Carries around a 6 Segment document for Subcontractors (Reference Company B - Participant 2)
        - May carry around drawings on iPad and access them in PDF format, for reference when talking to subcontractors; a printed schedule for update in the field.
        - Also uses SAFE in the field and sends/receives email.

    d. Which work documents would you produce in typical week?
        - Meeting agendas, Daily Reports, Quality Control Logs, Short-term Schedules, and Revision of Long-term Schedule.
        - Meeting Agenda - 1 Page Word Document
        - Short Term Schedule - Excel File extracted from Primavera Schedule. In this case, takes the detailed Primavera Schedule and combines detailed activities to simplify the schedule and create larger activities in Excel.

        - For Subs meetings: QC Action item logs, RFI log, submittal log (all three printed from Prolog), agenda (own Word document, printed), 4wk schedule (in Excel, printed), safety trends (from SAFE).

- Also monthly update of project schedule

e. Are these documents provided by your firm, developed by yourself?
    - Schedule (Short-term Excel File) - Takes company generic document and "tweeks" format slightly to fit to his project requirements and attributes.
    - Changes to the schedule include format, divide tasks by levels and areas, not floors
    - Trend charts developed on his own.
    - Punchlists for gathering information in the field.

2. To what extent do you utilize the software mentioned in the survey (ref survey) to collect and distribute information for these work documents?
    - N/A
    - See questions 1d and 1e

3. Are these information technologies being utilized in conjunction with HHC's/Mobile Devices, 3-D Modeling, Misc Info Focal Points (email, Share Drives, BIM), Software, etc.?
    - Utilizes IPhone and Adobe PDF Reader to access PDF files in the field. (Drawings, RFI's, etc.)
    - Utilizes IPad in the field along with Adobe Viewer. Takes snap shots of drawings and utility sketches and uses during inspections.
    - In the office uses Adobe Pro to cloud plans and specs. Usually to help answer RFI's or mark plans changes, and then redistributes to the architect and whoever else needs them.
    - IPad with Prolog in the field to access information (RFI's, etc.)
    - IPad used with S.A.F.E program (company designed program). S.A.F.E. is a web-based program that allows you to look at trends in terms of onsite safety hazards (behavioral or equipment related). Information can be checked in the field with the use of an IPad or during meetings, to see what people are doing wrong and right. Each entry is assigned a time stamp and when information was entered. Specifically implies safety hazards (i.e. wrong tool, etc.)
    - Subject commented that “there is not a lot of data entry in the field.

4. When does the use of the software mentioned help you? (i.e. provide specific information, time benefits, facilitate process, distribute information, etc.) Please mention particular functions that aid your onsite decisions, including meetings and inspections.
    - Ref answer 3.

- Prolog keeps things consistent, a lot of data input initially but makes information more readily available to everyone. Also, different project positions can use Prolog for different documents that they can format according to their needs, Prolog is very versatile.
- In general, it's convenient to access information quickly—not necessarily real time.
- Email helps to follow-up on conversations and is helpful when trying to reach a lot of people simultaneously.

5. When does it get in the way? (i.e. difficult to understand/communicate, time consuming, inadequate results, unable to share information, etc.). Please mention particular functions that are inadequate for your purposes.
    - IPhone screen can be too small for checking PDF's sometimes.
    - IPad's can be "large" and "clunky" to carry around the site.
    - It can be tough to search through PDF's in the field on the IPad. PDF files themselves sometimes cause issues. The word search function will not work properly. Therefore, you can't efficiently search through the specs or plans in the field.
    - Technology can take away from face-to-face interactions
    - Must rely way too much on technology. If technology goes down or fails, can often lead to delays or issues in the field.
    - Particularly, too much reliance on email and even texting, which takes away from face to face interactions
    - Subject commented that if Prolog goes down, everything goes down, meaning that much work stops if Prolog cannot be accessed.

6. Based on your current methods (i.e. paper-based, HHC, etc.), what information do you find the most difficult to collect, maintain, and organize **onsite**?
    - Mark-up drawings in the field -- goes back to office to perform this work.
    - Tough to search through PDF's in the field.
    - Use of Prolog or another Project Controls program in the field with an IPad would be useful. However, would have to be set up such that it has pull-down menus (this is very important). Open-ended writing makes it difficult to search through various documents. Pull-down menus makes it easier to search through various documents and information.

    - Use of Prolog or another Quality Controls program in the field with an IPad would be useful. However, would have to be set up such that it has pull-down menus (this is very important). Open-ended writing makes it difficult to search through various documents. Pull-down menus makes it easier to search through various documents and information.

7. Does your current process of developing documents (1d) facilitate communication between stakeholders and allow you to make adequate onsite decisions? Could you provide an example?
    - Current process is OK, may could be a few instances where company could make improvements.
    - In general, the documents they are able to put together is balanced—not too many, not too few.

8. Do you feel your company could improve the following construction activities/processes with the use of better software or information technologies? (Reference survey, which software they use)

    Design/Specs: ***Yes*** No
    If yes, how? With what technologies?
    - Would be a huge benefit to have daily updated plans, specs, etc on the IPad in the field.

    If no, are you aware of any beneficial technologies associated with this activity?
    - **Bluebeam** used in the field with an IPad. Allows you to link drawings to specific specifications and details. Would be helpful for inspections.
    - It can be tough to search through PDF's in the field on the IPad. PDF files themselves sometimes cause issues. The word search function, which is very useful in some instances, will not work properly. Therefore, you can't efficiently search through the specs or plans in the field. **Bluebeam** would make it easier to search through the plans or specs in the field.
    - Current use of Adobe and Revit is adequate.

    Material Management: ***Yes*** No
    If yes, how? With what technologies?

    If no, are you aware of any beneficial technologies associated with this activity?
    - The need for live data in terms of material arrival could be beneficial. This could be done with **Prolog** (which the company currently has). Although, provided the size and nature of the current project interviewee is on, it may not be as beneficial. May find it more beneficial on an industrial project.
    - Current practices of tracking are sufficient even for larger projects such as Spring Condos.

    Project Controls: Yes ***No***
    If yes, how? With what technologies?

    If no, are you aware of any beneficial technologies associated with this activity?

- Prolog currently does everything they need for this process. Including Daily Reports, Schedule Updates, etc.
- Use of Prolog or another Project Controls program in the field with an IPad would be useful. However, would have to be set up such that it has pull-down menus (this is very important). Open-ended writing makes it difficult to search through various documents. Pull-down menus makes it easier to search through various documents and information.

Quality Control: ***Yes*** No
If yes, how? With what technologies?

If no, are you aware of any beneficial technologies associated with this activity?

- Prolog currently does everything they need for this process. Including QC Inspection Logs.
- Use of Prolog or another Quality Controls program in the field with an IPad would be useful. However, would have to be set up such that it has pull-down menus (this is very important). Open-ended writing makes it difficult to search through various documents. Pull-down menus makes it easier to search through various documents and information.
- Company is moving towards performing QC inspections in the field w/ the use of a tablet.

Safety: Yes ***No***
If yes, how? With what technologies?

If no, are you aware of any beneficial technologies associated with this activity?

- Current S.A.F.E. program is good. Breaksdown information into behavioral or equipment related hazards. Made up of dropdown menus. Provides easy access to all offices allowing the headquarters office to see who is tracking what and how often they are performing safety inspections.

Project Delivery: Yes ***No***
If yes, how? With what technologies?

If no, are you aware of any beneficial technologies associated with this activity?

Company B – Interview 5

Position: Project Superintendent
Industry Experience:
Years of experience in current position – 8 yrs
Years of experience with current company – 13 yrs
Years of experience in the industry – 18 yrs

1. Provided the general scenario:
   a. In which instances would you engage in this process? – Collect information, develop documents

   b. In which instances would you pull that information back for your use? – Specific meetings, inspections
      - Uses 90-day schedules at meetings on iPad
      - Trend charts are used at meetings; typically posted on the wall of the conference room.

   c. In the survey, you responded that you are _____ to take these documents for meetings and inspections. To elaborate on your response, please tell us if you carry around the documents for personal reference/as reference during meetings /as meeting handouts/or distribution?
      - Updates schedules (see answer (d.)) himself; brings to meetings. Generally uses 90-day schedules at meetings (in the field or in the office) on iPad/iPhone.
      - Also brings paper drawings into meetings. Particularly for subcontractors' meetings, he relies on trend charts hung on the conference room, since they can be easier to explain than schedules—many subs don't get schedules.

   d. Which work documents would you produce in typical week?
      - Project Schedules - Develops a very detailed Master Project Schedule; detailed to the week to create uniformity amongst all schedules
        - Pulls 90-day and 1-week look ahead schedules from Master Schedule
      - Trend/Progress Charts
      - Daily Reports (Prolog)

   e. Are these documents provided by your firm, developed by yourself?
      - Trend charts are standardized by company
      - Schedules are NOT standardized - All company sites use Primavera P6, but some sites vary with regard to how they develop their look-ahead schedules. Some even utilize difference software (Excel vs. P6).

2. To what extent do you utilize the software mentioned in the survey (ref survey) to
   a. collect and
   b. distribute information for these work documents?
      - Prolog for daily reports
      - Primavera P6 to develop and update schedules
      - Safety software to collect onsite safety check information
      - Bluebeam for marking up, sharing and sending documents
      - Uses Navisworks for accessing 3D model

3. Are these information technologies being utilized in conjunction with HHC's/Mobile Devices, 3-D Modeling, Misc Info Focal Points (email, Share Drives, BIM), Software, etc.?
      - Tablets used in the field (used to review 2D drawings, to review spreadsheets, and SAFE software) – it took a while to figure out how to pull drawings, now trying to pull spreadsheets too
      - BIM Kiosk used in the field to review BIM.
        - Check the model in the field and can make changes at the Kiosk.
        - Can print drawings from Kiosk. Mostly used as a visual aid to provide clarification to specific jobsite tasks.
        - Can markup model in field and send to engineer for changes to construction and as-built model.

4. When does the use of the software mentioned help you? (i.e. provide specific information, time benefits, facilitate process, distribute information, etc.) Please mention particular functions that aid your onsite decisions, including meetings and inspections.
      - BIM - Used for modeling piping and MEP work; Clash detection - easier to make changes in the field. Saves time throughout the entire project process. Construction and BIM is better than Construction and pre-planning (w/ out BIM).
        - 4D Simulations (BIM)
        - Fabrication of systems and materials based off the model. (BIM)
      - Tablets in the field - Access trend spread sheets and schedule

5. When does it get in the way? (i.e. difficult to understand/communicate, time consuming, inadequate results, unable to share information, etc.). Please mention particular functions that are inadequate for your purposes.
      - Trying to get people trained and caught up on technology
      - iPad doesn't work well w/ 2D/3D drawings. BIM tends to freeze up the iPad. "The iPad is not ready for construction."
      - Prolog is not user friendly for document organization ("took 6 hrs to print", and couldn’t troubleshoot)

- Some "Owners" request specific software to be used for a project and project personnel are not trained on it.
- Sometimes paper-based documents are quicker to access and sometimes easier to communicate with field workers

6. Based on your current methods (i.e. paper-based, HHC, etc.), what information do you find the most difficult to collect, maintain, and organize onsite?
    - QC/QA personnel collecting QC info w/ paper-based forms. Should move to an electronic format.

7. Does your current process of developing documents (1d) facilitate communication between stakeholders and allow you to make adequate onsite decisions? Could you provide an example?
    - Currently, there are too many documents involved in "our" processes.
    - Electronic drawings/documents allows you to keep documents current.

8. Do you feel your company could improve the following construction activities/processes with the use of better software or information technologies? (Reference survey, which software they use)

    Design/Specs: ***Yes*** No
    If yes, how? With what technologies?
    - iPads are hard to use in the field, particularly for visualizations
    - All about the ability to view 2D/3D drawings in the field.

    If no, are you aware of any beneficial technologies associated with this activity?

    Material Management: ***Yes*** No
    If yes, how? With what technologies?
    - Smart tags (RFID) - use to track delivery
    - Potentially Vela Systems

    If no, are you aware of any beneficial technologies associated with this activity?

    Project Controls: Yes ***No***
    If yes, how? With what technologies?

    If no, are you aware of any beneficial technologies associated with this activity?

    Quality Control: ***Yes*** No
    If yes, how? With what technologies?
    - Smart tags (RFID) in conjunction w/ spread sheet forms - Vela Systems

If no, are you aware of any beneficial technologies associated with this activity?

Safety: Yes ***No***

If yes, how? With what technologies?

If no, are you aware of any beneficial technologies associated with this activity?

Project Delivery: ***Yes*** No

If yes, how? With what technologies?

- Using Vela for punch listing and commissioning (database)
- Normally uses excel spreadsheet w/ "50,000 rows"
- Vela Systems to track O&M information for owner.

If no, are you aware of any beneficial technologies associated with this activity?

Company B –Interview 6

Position: Project Superintendent
Industry Experience:
Years of experience in current position – 7 yrs
Years of experience with current company – 15 yrs
Years of experience in the industry – 15 yrs

1. Provided the general scenario:
   a. In which instances would you engage in this process? – Collect information, develop documents

   b. In which instances would you pull that information back for your use? – Specific meetings, inspections
      - Most documentation the interviewee has memorized; therefore, does not necessarily have to bring documents to meetings.

   c. In the survey, you responded that you are _____ to take these documents for meetings and inspections. To elaborate on your response, please tell us if you carry around the documents for personal reference/as reference during meetings /as meeting handouts/or distribution
      - Brings progress schedules to meetings and uses the trend charts and site utilization plants located in the conference room for support.

   d. Which work documents would you produce in typical week?
      - Schedule updates
      - Daily Reports

   e. Are these documents provided by your firm, developed by yourself?
      - Most documents standardized; although different "standardized" document formats are updated often.

2. To what extent do you utilize the software mentioned in the survey (ref survey) to
   a. collect and
   b. distribute information for these work documents?
      - Field Engineers have iPads; Superintendents will go to FE's and use the iPad together to access necessary information.
      - Bluebeam to access RFI's and shop drawings; Bluebeam provides the ability to attach RFI's to drawings and their associated activity or materials.

3. Are these information technologies being utilized in conjunction with HHC's/Mobile Devices, 3-D Modeling, Misc Info Focal Points (email, Share Drives, BIM), Software, etc.?
    - iPad w/ Bluebeam in the field.

4. When does the use of the software mentioned help you? (i.e. provide specific information, time benefits, facilitate process, distribute information, etc.) Please mention particular functions that aid your onsite decisions, including meetings and inspections.
    - BIM - virtual construction; ultimately, being able to build the project electronically before building it in the field.
        - Downloading BIM information into total stations (surveying) to locate utilities.
    - Digitalized submittals; accessible by iPads, holds all spec information needed for inspections.
    - PDF Bluebeam and edit capabilities; used in conjunction w/ iPads - accessing RFI's from iPads and everyone has access to the same updated drawings.
    - iPads are a "one shop stop of information to not do half-ass inspections"

5. When does it get in the way? (i.e. difficult to understand/communicate, time consuming, inadequate results, unable to share information, etc.). Please mention particular functions that are inadequate for your purposes.
    - Prolog - not sortable; for the construction industry Prolog is not good; very slow, Excel and P6 are better to keep information organized
    - When technology fails; people rely too much on technology; can shut down a project.
    - Interoperability of new technology and software with existing technology and software's you are using.
    - Double handling of information; having to produce paper-based and electronic information for one activity.
    - Biggest waste is double/triple handling of the same documents, technologies fighting for the same piece of information. There are no resources (time, money) to track things twice. This is an indication of technologies that are not well integrated. For example, "you have to go all-in when going digital", otherwise you are tracking things twice, and you end up spending time and money on implementations that are likely to be unsuccessful.

6. Based on your current methods (i.e. paper-based, HHC, etc.), what information do you find the most difficult to collect, maintain, and organize onsite?
    - No.

7. Does your current process of developing documents (1d) facilitate communication between stakeholders and allow you to make adequate onsite decisions? Could you provide an example?
    - Adequate, as long as others read it—it's as good as the receiver.

8. Do you feel your company could improve the following construction activities/processes with the use of better software or information technologies? (Reference survey, which software they use)

    Design/Specs: Yes ***No***
    If yes, how? With what technologies?

    If no, are you aware of any beneficial technologies associated with this activity?

    Material Management: Yes ***No***
    If yes, how? With what technologies?

    If no, are you aware of any beneficial technologies associated with this activity?

    Project Controls: Yes ***No***
    If yes, how? With what technologies?

    If no, are you aware of any beneficial technologies associated with this activity?

    Quality Control: Yes ***No***
    If yes, how? With what technologies?

    If no, are you aware of any beneficial technologies associated with this activity?

    Safety: Yes ***No***
    If yes, how? With what technologies?

    If no, are you aware of any beneficial technologies associated with this activity?

    Project Delivery: ***Yes*** No
    If yes, how? With what technologies?
    - Vela Systems - track O&M information to deliver to the owner.

    If no, are you aware of any beneficial technologies associated with this activity?

Company B – Interview 7

Position: Area Superintendent
Industry Experience:
Years of experience in current position – 2 yrs
Years of experience with current company – 8 yrs
Years of experience in the industry – 8 yrs

1. Provided the general scenario:
   a. In which instances would you engage in this process? – Collect information, develop documents

   b. In which instances would you pull that information back for your use? – Specific meetings, inspections
      - Bluebeam @ meetings to reference drawing and site info.
      - Print updated schedules for meetings once a week (3-week look-aheads)
        - Updates schedules 3 times a week
        - Uses for meetings in the field.
      - Occasionally produces sketches by hand in the field to support inspections
      - If sketch is important, hands it to the field engineer to draw up in AutoCAD.

   c. In the survey, you responded that you are _____ to take these documents for meetings and inspections. To elaborate on your response, please tell us if you carry around the documents for personal reference/as reference during meetings /as meeting handouts/or distribution?
      - See (b.)

   d. Which work documents would you produce in typical week?
      - See (b.)
      - In-field sketches
      - SAFE Reports - collected on iPad or iPhone in the field
      - Schedules
      - Daily Reports (in Excel)

   e. Are these documents provided by your firm, developed by yourself?
      - Majority of the documents are standardized including SAFE, schedules, and HP portal website (has rules and regulations)

2. To what extent do you utilize the software mentioned in the survey (ref survey) to
   a. collect and
   b. distribute information for these work documents?
      - Utilizes the server (provides updates specs) and Prolog (utilized to track changes) to reference project specifications.

- Bluebeam - used for updating and referencing drawings, connecting RFI's to drawings, and managing and locating materials in material laydown areas

3. Are these information technologies being utilized in conjunction with HHC's/Mobile Devices, 3-D Modeling, Misc Info Focal Points (email, Share Drives, BIM), Software, etc.?
    - SAFE used in conjunction w/ iPad and iPhones (i.e. tablets); the software presents a comprehensive checkbox format - this "Speeds up the information collect process"
    - Field Engineers use iPads in conjunction with inspections - Superintendents will use field engineers and their tablets to bring up information for their inspections.

4. When does the use of the software mentioned help you? (i.e. provide specific information, time benefits, facilitate process, distribute information, etc.) Please mention particular functions that aid your onsite decisions, including meetings and inspections.
    - Scheduling - accessing (in the field) , creating and building schedules; Primavera P6 speeds up scheduling process vs Excel by providing quicker access and creation of documents
    - E-mail - for documentation; NOT for communication purposes—face-to-face or phone are faster
    - Meetings and Organization- setting up meetings and organizing documents

5. When does it get in the way? (i.e. difficult to understand/communicate, time consuming, inadequate results, unable to share information, etc.). Please mention particular functions that are inadequate for your purposes.
    - Prolog - Prolog is slow, not user friendly—even with custom forms; reduces efficiency; ultimately the program relies too heavily on the internet.
    - Software for accounting and excel is not interoperable with Prolog; as a result, the interviewee has to create the same cost summary documents several times for different software.

6. Based on your current methods (i.e. paper-based, HHC, etc.), what information do you find the most difficult to collect, maintain, and organize onsite?
    - Struggle to keep RFI's up to date in conjunction with drawings; there are too many RFI's to track sometimes regardless of the software assistance available.
    - Currently uses Bluebeam to link RFI's to drawings; this is the best way interviewee has seen it done so far.

7. Does your current process of developing documents (1d) facilitate communication between stakeholders and allow you to make adequate onsite decisions? Could you provide an example?

- Mostly adequate

8. Do you feel your company could improve the following construction activities/processes with the use of better software or information technologies? (Reference survey, which software they use)

Design/Specs: Yes ***No***
If yes, how? With what technologies?

If no, are you aware of any beneficial technologies associated with this activity?

Material Management: ***Yes*** No
If yes, how? With what technologies?
- Prolog used for submittal tracking and deliverables, but Prolog doesn't easily align submittal tracking & deliverables.
- Excel can perform this task better.

If no, are you aware of any beneficial technologies associated with this activity?

Project Controls: Yes ***No***
If yes, how? With what technologies?

If no, are you aware of any beneficial technologies associated with this activity?

Quality Control: Yes ***No***
If yes, how? With what technologies?

If no, are you aware of any beneficial technologies associated with this activity?

Safety: Yes ***No***

If yes, how? With what technologies?

If no, are you aware of any beneficial technologies associated with this activity?

Project Delivery: Yes ***No***
If yes, how? With what technologies?

If no, are you aware of any beneficial technologies associated with this activity?

Company C – Interview 1

Position: Technical Services Specialist
Industry Experience:
Years of experience in current position – 1.5 years
Years of experience with current company – 7 years
Years of experience in the industry – 18 years

1. Provided the general scenario:
    a. In which instances would you engage in this process? – Collect information, develop documents
        - When using iPIMs and PMM to pull up drawings and specifications

    b. In which instances would you pull that information back for your use? – Specific meetings, inspections
        - Meetings with Foreman, Superintendents, and Clients
        - Meetings with Pipe General Foreman; uses excel spread sheets to track items for Turnover process. Helps to develop a game plan as to when project components will be ready to turnover.
        - Brings system P&ID's for walks with the clients

    c. In the survey, you responded that you are _Very Likely_ to take these documents for meetings and inspections. To elaborate on your response, please tell us if you carry around the documents for personal reference/as reference during meetings /as meeting handouts/or distribution?
        - Brings system P&ID's for walks with the clients; uses Adobe Pro to highlight and redline P&ID's back at the office, essentially breaking the pipe segments into systems; uses Adobe Pro to note things the client would like to see. Also produces a sign-in/-out sheet for walks with the client.
        - Prints out system turnover tracker for meeting with subcontractors.

    d. Which work documents would you produce in typical week?
        - Ultimately gathers and collects information for work packages.
        - iPIM's and PMM (Performance Measurement Module) - reviews drawings and specifications and ISO's
        - Finds ISO's info for field personnel (Ex. finds specifications and will save to work package file)

    e. Are these documents provided by your firm, developed by yourself?
        - Spreadsheets created by someone else to track turnover, but she provides them the information to create the spreadsheets

- These spreadsheets are shared with superintendents and foreman in the field.

2. To what extent do you utilize the software mentioned in the survey (ref survey) to
    a. collect and
    b. distribute information for these work documents?
        - Actively uses iPIMS, Acrobat and Excel. See examples above.

3. Are these information technologies being utilized in conjunction with HHC's/Mobile Devices, 3-D Modeling, Misc Info Focal Points (email, Share Drives, BIM), Software, etc.?
    - iPhones to take pictures
    - Pen and paper to take notes in the field

4. When does the use of the software mentioned help you? (i.e. provide specific information, time benefits, facilitate process, distribute information, etc.) Please mention particular functions that aid your onsite decisions, including meetings and inspections.
    - iPim's allows interviewee to put together test packages in a few simple clicks
    - Welding database to track welds; which can help determine if welds have been completed and the progress of testing.
    - The integration and automatic updating of their systems saves a lot of time.
    - The model is very helpful to determine elevations and access to pipes for test packages.

5. When does it get in the way? (i.e. difficult to understand/communicate, time consuming, inadequate results, unable to share information, etc.). Please mention particular functions that are inadequate for your purposes.
    - No.

6. Based on your current methods (i.e. paper-based, HHC, etc.), what information do you find the most difficult to collect, maintain, and organize onsite?
    - No; good integration of project entities. **Everyone is good at putting their information in the network and it is easy to pull it out.**

7. Does your current process of developing documents (1d) facilitate communication between stakeholders and allow you to make adequate onsite decisions? Could you provide an example?
    - Yes

8. Do you feel your company could improve the following construction activities/processes with the use of better software or information technologies? (Reference survey, which software they use)

Design/Specs: Yes ***No***
If yes, how? With what technologies?

If no, are you aware of any beneficial technologies associated with this activity?

Material Management: Yes ***No***
If yes, how? With what technologies?

If no, are you aware of any beneficial technologies associated with this activity?

Project Controls: Yes ***No***
If yes, how? With what technologies?

If no, are you aware of any beneficial technologies associated with this activity?

Quality Control: Yes ***No***
If yes, how? With what technologies?

If no, are you aware of any beneficial technologies associated with this activity?

Safety: Yes ***No***
If yes, how? With what technologies?

If no, are you aware of any beneficial technologies associated with this activity?

Project Delivery: ***Yes*** No
If yes, how? With what technologies?

- Weld Maps in iPIMs w/ work packages could be useful, as opposed to having a file on the central network.

If no, are you aware of any beneficial technologies associated with this activity?

Company C – Interview 2

Position: Field Engineer
Industry Experience:
Years of experience in current position – 6 years in Tech Services
Years of experience with current company – 1.5 years
Years of experience in the industry – 11 years (1.5 in Project Controls, 3 years as an intern)

1. Provided the general scenario:
    a. In which instances would you engage in this process? – Collect information, develop documents

    b. In which instances would you pull that information back for your use? – Specific meetings, inspections
        - Field Meetings - Develops notes during field meetings (by hand) to bring back to the office. Collects Tag #'s, etc.
        - In-Office Meetings (Internal Meetings and Client Meetings) - Often utilizes 3D (BIM) Model, RFI's, FCO's (Field Change Orders) during meetings in electronic format. Also, uses electronic tracking tools and summary reports during meetings.
        - Meetings with clients, vendors, field personnel

    c. In the survey, you responded that you are _____ to take these documents for meetings and inspections. To elaborate on your response, please tell us if you carry around the documents for personal reference/as reference during meetings /as meeting handouts/or distribution?
        - Ref 1.b
        - Uses the contents of iPIMS and the 3D model for everyone's reference during the meeting. The system turnover tracking document can be printed sometimes.

    d. Which work documents would you produce in typical week?
        - Tracking Tools for employees and resources, including schedules, trends, system turnover tracking document, and summary reports.

    e. Are these documents provided by your firm, developed by yourself?
        - Documents produced by firm; most documents standardized.
        - RFI's and FCO's; company standard

2. To what extent do you utilize the software mentioned in the survey (ref survey) to
    a. collect and

- Typically info is collected by others for entry into software (i.e. iPIM's, Wintegrate, and Oracle) . Info collected in the field done by hand.
- Collects info from previous projects to analyze and determine procurement strategy and to answer RFI's.

b. distribute information for these work documents?
- All info input into iPIMs by interviewee is accessible by all field personnel (w/ accessible laptop)

3. Are these information technologies being utilized in conjunction with HHC's/Mobile Devices, 3-D Modeling, Misc Info Focal Points (email, Share Drives, BIM), Software, etc.?
- Typical works in the office. Uses standard laptop or PC. May use a camera in the field.

4. When does the use of the software mentioned help you? (i.e. provide specific information, time benefits, facilitate process, distribute information, etc.) Please mention particular functions that aid your onsite decisions, including meetings and inspections.
- iPIMs - pull back information for use (i.e. RFI's from previous projects to answer current RFI's)
  - Great moving forward because RFI's overlap throughout projects...Fraq 7 and 8 RFI's repoeat by nature (Includes pictures and Engineering Notes) and there is no need to request this information to anybody.
  - Helps track and determine procurement time based on historical data.
- 3D Model particularly helpful for the communication process; brings clarity.

5. When does it get in the way? (i.e. difficult to understand/communicate, time consuming, inadequate results, unable to share information, etc.). Please mention particular functions that are inadequate for your purposes.
- Nothing; issues only occur when people put crap-in which equals crap-out.
- Also, issues are caused when people won't conform to tools.

6. Based on your current methods (i.e. paper-based, HHC, etc.), what information do you find the most difficult to collect, maintain, and organize onsite?
- Drawings and Markups - Specifically in regard to "how do you organize that information between parties, this can be difficult.
- Current Method Utilized: Mark-ups sent to interviewee (sometimes electronically and sometimes hardcopy); interviewee sends to engineering to upload in real-time to iPIM's which is then accessible to all

7. Does your current process of developing documents (1d) facilitate communication between stakeholders and allow you to make adequate onsite decisions? Could you provide an example?
    - Yes, it does facilitate communication. For example, the use of the 3D model (see question 4).

8. Do you feel your company could improve the following construction activities/processes with the use of better software or information technologies? (Reference survey, which software they use)

    Design/Specs: Yes ***No***
    If yes, how? With what technologies?

    If no, are you aware of any beneficial technologies associated with this activity?
    - Everyone has access to the model

    Material Management: Yes ***No***
    If yes, how? With what technologies?
    - Based on current methods, warehouse uploads arrival time of materials in real-time on iPIMs/Wintegrate accessible to all
    - Tools and barcoded and tracked; Equipment has GPS

    If no, are you aware of any beneficial technologies associated with this activity?

    Project Controls: ***Yes*** No
    If yes, how? With what technologies?
    - Electronic spread sheets
    - Use of electronic tools in the field
    - PDAs could be used instead of paper-based time sheets

    If no, are you aware of any beneficial technologies associated with this activity?

    Quality Control: Yes ***No***
    If yes, how? With what technologies?
    - iPads on site could be useful for real time updates (intrinsically unsafe device in for these projects; so can't have onsite)

    If no, are you aware of any beneficial technologies associated with this activity?

    Safety: Yes ***No***
    If yes, how? With what technologies?
    - Corporate database – electronic, as well as current safety procedures and meetings, work well to get info out to everyone

If no, are you aware of any beneficial technologies associated with this activity?

Project Delivery: Yes ***No***
If yes, how? With what technologies?

- Current Methods:
    - People Tools; Excel Spreadsheets, shows loops status

If no, are you aware of any beneficial technologies associated with this activity?

Company C – Interview 3

Position: Piping Activity Planner
Industry Experience:
Years of experience in current position – 2 years
Years of experience with current company – 4 years
Years of experience in the industry – 11-12 years

1. Provided the general scenario:
    a. In which instances would you engage in this process? – Collect information, develop documents
        - Sits down with Superintendents go over piping ISO's broken down based on activities - Applies information to ISO's (planner information, vendors...work package info)
        - Follow up; trial allocation of material based on schedule and area.

    b. In which instances would you pull that information back for your use? – Specific meetings, inspections
        - Field Meetings - Does not bring info for field meetings; takes simple notes. Typically, meets with superintendents and general foreman.

    c. In the survey, you responded that you are _____ to take these documents for meetings and inspections. To elaborate on your response, please tell us if you carry around the documents for personal reference/as reference during meetings /as meeting handouts/or distribution?
        - Very unlikely, only if someone else requests a specific document

    d. Which work documents would you produce in typical week?
        - Pipe Audit Spread Sheet -updated in real-time and available to all - general foreman, foremen, superintendents
        - Foreman will let interviewee know what work he wants to perform, in turn, interviewee will set up ISO packages & track dates of materials and associated work
        - Field work plans, to plan for information that crews will need; 3wk look ahead schedule, to track man-hours per field work plan; ISO tracking spreadsheet, to track testing—this is also accessed by clerks and foremen; ISO sign off log—**in this document he came up with his own chart to tell if someone's behind on signing off ISOs.**

    e. Are these documents provided by your firm, developed by yourself?
        - S&B tries to make documents as standard as possible. Interviewee will make tweaks and changes to spreadsheets when necessary and to expand

on information (i.e. tracks specific foreman or will develop ISO % complete vs. actual manpower)
- Also see Question 7.

2. To what extent do you utilize the software mentioned in the survey (ref survey) to
    a. collect and
        - Excel Sheets & Graphs which track ISO's.

    b. distribute information for these work documents?
        - Uploaded to iPIM's for field personnel access
        - Pipe Audit Spread Sheet -updated in real-time and available to all - general foreman, foremen, superintendents
        - Foreman will let interviewee know what work he wants to perform, in turn, interviewee will set up ISO packages & track dates of materials and associated work

3. Are these information technologies being utilized in conjunction with HHC's/Mobile Devices, 3-D Modeling, Misc Info Focal Points (email, Share Drives, BIM), Software, etc.?
    - General Foreman have laptops in the field to access information interviewee produces
    - P&ID - Piping and information Diagrams

4. When does the use of the software mentioned help you? (i.e. provide specific information, time benefits, facilitate process, distribute information, etc.) Please mention particular functions that aid your onsite decisions, including meetings and inspections.
    - Helps with early detection with regard to tracking particular foreman and what ISO's they've signed-off on and the ISO's incompleteness.
    - Tracks specific foreman or will develop ISO % complete vs. actual manpower; information collected helps to decide where to allocate resources based on progress of particular crafts and positions (for example: helps determine if behind on sign-off ISO's), and the fact that the spreadsheet is updated live automates a portion of the process of sharing information from person to person.

5. When does it get in the way? (i.e. difficult to understand/communicate, time consuming, inadequate results, unable to share information, etc.). Please mention particular functions that are inadequate for your purposes.
    - Server speed in the field can be an issue (i.e. download and upload speed) for spreadsheets

6. Based on your current methods (i.e. paper-based, HHC, etc.), what information do you find the most difficult to collect, maintain, and organize onsite?
    - Tracking information of material in the warehouse; the main issue is the interviewee and warehouse have differing programs and it's hard to determine who has ownership of info.

7. Does your current process of developing documents (1d) facilitate communication between stakeholders and allow you to make adequate onsite decisions? Could you provide an example?
    - If missing information interviewee will tailor spreadsheets to superintendents needs and styles. Often happens at the beginning of the project. For example, will add columns regarding spools and footage left; hours of work remaining for a particular activity; efficiency index - helps track productivity

8. Do you feel your company could improve the following construction activities/processes with the use of better software or information technologies?

    Design/Specs: Yes ***No***
    If yes, how? With what technologies?
    If no, are you aware of any beneficial technologies associated with this activity?

    Material Management: Yes ***No***
    If yes, how? With what technologies?
    If no, are you aware of any beneficial technologies associated with this activity?

    Project Controls: Yes ***No***
    If yes, how? With what technologies?
    If no, are you aware of any beneficial technologies associated with this activity?

    Quality Control: Yes ***No***
    If yes, how? With what technologies?
    If no, are you aware of any beneficial technologies associated with this activity?

    Safety: Yes ***No***
    If yes, how? With what technologies?
    If no, are you aware of any beneficial technologies associated with this activity?

    Project Delivery: Yes ***No***
    If yes, how? With what technologies?
    If no, are you aware of any beneficial technologies associated with this activity?

Company C – Participant 4

Position: Project Superintendent
Industry Experience:
Years of experience in current position – 15 years
Years of experience with current company –
Years of experience in the industry – 30 years (piping and rigging activities)

1. Provided the general scenario:
    a. In which instances would you engage in this process? – Collect information, develop documents

    b. In which instances would you pull that information back for your use? – Specific meetings, inspections
        - In the office - Utilizes spread sheets for tracking of personnel and materials
        - Meetings - Utilizes spreadsheets for spools; in other words, what's coming in and what stages the spool fabrication is coming in. Cross checks this information with other superintendents.
        - Meetings with the owner, general foremen, other superintendents
        - Use field work plans to balance out work for foremen

    c. In the survey, you responded that you are _____ to take these documents for meetings and inspections. To elaborate on your response, please tell us if you carry around the documents for personal reference/as reference during meetings /as meeting handouts/or distribution?
        - Meetings w/ Foreman - Utilizes E.I. (Efficiency Factor) sheets to check with foreman to try and understand issues w/ productivity. (For example, identify materials they may be missing). Interviewee will bring hardcopies of E.I. sheets to the field or may go into the field office to look at the sheets electronically. He will print out reports and pull them out for reference.
        - Also, has meetings with clients (occasionally).

    d. Which work documents would you produce in typical week?
        - Spreadsheets and reports to compare to the schedule and see what spool pieces correlate to the work to be performed. (Cross references this info with warehouse to see if material necessary is available). Not as concerned with tools and equipment.

    e. Are these documents provided by your firm, developed by yourself?
        - Utilizes standard company sheets.

- If sees issue with standard sheet, interviewee will direct inquiry to John Perkins (Pipe Craft Planner). Interviewee, typically asks others to tailor spread sheets to meet the foreman's needs. (Ex. hours, spool necessary (for each field work plan) - this info makes it easy to review and determine the distribution of workloads amongst foremen.)

2. To what extent do you utilize the software mentioned in the survey (ref survey) to
    a. collect and
    b. distribute information for these work documents?
        - Ref. Question 1 & 3.

3. Are these information technologies being utilized in conjunction with HHC's/Mobile Devices, 3-D Modeling, Misc Info Focal Points (email, Share Drives, BIM), Software, etc.?
    - Spread sheets discussed in Question 1, are used in conjunction with field office computers.

4. When does the use of the software mentioned help you? (i.e. provide specific information, time benefits, facilitate process, distribute information, etc.) Please mention particular functions that aid your onsite decisions, including meetings and inspections.
    - Having real-time update of completed work, spools coming to the site, and spools onsite.
        - This info helps plan work and in essence develop look-aheads
        - This info helps w/ thorough front-end planning and organization
    - Having the up-to-date model electronically for review and the general foremen review
    - Field personnel review this information on a daily basis to review ongoing activities and helps pull up information on project aspects (i.e. piping, etc - can use model to pull up tracking information or RFI's on particular project elements.)

5. When does it get in the way? (i.e. difficult to understand/communicate, time consuming, inadequate results, unable to share information, etc.). Please mention particular functions that are inadequate for your purposes.
    - No, if things get in the way...get rid of it.

6. Based on your current methods (i.e. paper-based, HHC, etc.), what information do you find the most difficult to collect, maintain, and organize onsite?
    - Reports in iPIM's sometimes are difficult to locate based on the extent of IT training.
        - To locate reports, you have to know exactly what you are looking for.
        - The foremen find this difficult to use.

7. Does your current process of developing documents (1d) facilitate communication between stakeholders and allow you to make adequate onsite decisions? Could you provide an example?
    - Yes.

8. Do you feel your company could improve the following construction activities/processes with the use of better software or information technologies? (Reference survey, which software they use)

    Design/Specs: Yes ***No***
    If yes, how? With what technologies?

    If no, are you aware of any beneficial technologies associated with this activity?

    Material Management: ***Yes*** No
    If yes, how? With what technologies?
    - Wintegrate can sometimes be difficult to pull reports or information off of. Needs to be clear if material is onsite or offsite. Could be improved.

    If no, are you aware of any beneficial technologies associated with this activity?

    Project Controls: Yes ***No***
    If yes, how? With what technologies?
    - Currently, efficient real-time updates for piping department, it is possible to feed off each other's reports.

    If no, are you aware of any beneficial technologies associated with this activity?

    Quality Control: Yes ***No***
    If yes, how? With what technologies?

    If no, are you aware of any beneficial technologies associated with this activity?
    - ISO sign off and testing are sufficient.

    Safety: Yes ***No***
    If yes, how? With what technologies?
    - Currently, uses "Zero to Sixty" reports; compiles information and distributes info to the entire company; general safety meetings every week are thorough.

    If no, are you aware of any beneficial technologies associated with this activity?

Project Delivery: Yes ***No***

If yes, how? With what technologies?

- Receives packages of info for punchlisting and turning over to client
    - Test packages are in there
    - Materials are in there
    - What spools and ISO's are in each package.

If no, are you aware of any beneficial technologies associated with this activity?

Company C – Participant 5

Position: Civil Superintendent
Industry Experience:
Years of experience in current position – 6.5 yrs
Years of experience with current company – 20 yrs
Years of experience in the industry – 23 yrs

1. Provided the general scenario:
    a. In which instances would you engage in this process? – Collect information, develop documents

    b. In which instances would you pull that information back for your use? – Specific meetings, inspections
        - Daily meetings with Foremen, General Foremen, Superintendents.
        - Inspections (paper based) - Equipment and Gators
        - Developing Schedules (3 or 4 hrs a day) - breaks down schedules and creates activity spreadsheets for each foreman

    c. In the survey, you responded that you are _____ to take these documents for meetings and inspections. To elaborate on your response, please tell us if you carry around the documents for personal reference/as reference during meetings /as meeting handouts/or distribution?
        - Notes, drawings, forms for ladders/fire extinguishers, and broken down schedules for meetings with foremen. Paper-based, used as reference except forms. (**unclear if forms were distributed**)

    d. Which work documents would you produce in typical week?
        - Through iPIMS: materials take off, access to drawings.
        - Planning of schedule (once a week to discuss look-aheads with foreman)
        - Access the 3D Model 1-3 times a week
        - Emails and phone calls following 811 calls (CBYD).

    e. Are these documents provided by your firm, developed by yourself?
        - Standard documents mostly.
        - Supervisor spreadsheet/checklist and training checklist are personalized by each department (ex. checklist to perform before you can call QC & checklist for training on equipment and tools) (**e.g. which departments? Piping, carpenters, concrete?**).

2. To what extent do you utilize the software mentioned in the survey (ref survey) to

a. collect and
b. distribute information for these work documents?
    - Some use of iPIMS in the office. All documents are paper-based.

3. Are these information technologies being utilized in conjunction with HHC's/Mobile Devices, 3-D Modeling, Misc Info Focal Points (email, Share Drives, BIM), Software, etc.?
    - Only his surveyors utilize data from the total station and they check the data in the computer before sharing with the engineers.

4. When does the use of the software mentioned help you? (i.e. provide specific information, time benefits, facilitate process, distribute information, etc.) Please mention particular functions that aid your onsite decisions, including meetings and inspections.
    - Use of RFID for power tools (for tracking tools), lasers for cutting grate, camera for reversing heavy equipment, sensors for metal detection tools.
    - Screens installed in common areas for communication of safety information.
    - Access to the model: reduces printing costs, time necessary to plan or meetings, real-time changes can be made during the meetings.
    - 3D Model - reviewing revisions of drawings

5. When does it get in the way? (i.e. difficult to understand/communicate, time consuming, inadequate results, unable to share information, etc.). Please mention particular functions that are inadequate for your purposes.
    - Sometimes when it is necessary to wait for data or documents that are not accessible. No cell phones are allowed in the plant, so it is difficult to remember phone numbers on site. Overall, it is difficult to go back from automated processes to doing them by hand**--troubleshooting**.

6. Based on your current methods (i.e. paper-based, HHC, etc.), what information do you find the most difficult to collect, maintain, and organize onsite?
    - Sometimes it is difficult to find files in the computer.
    - Can be difficult to keep things organized and relocate information on the computer.

7. Does your current process of developing documents (1d) facilitate communication between stakeholders and allow you to make adequate onsite decisions? Could you provide an example?
    - Mostly yes, although there are always information gaps, especially during meetings. Learning more about basic computer usage would be helpful because otherwise it is difficult and time consuming to figure out on your own.

8. Do you feel your company could improve the following construction activities/processes with the use of better software or information technologies? (Reference survey, which software they use)

Design/Specs: Yes ***No***
If yes, how? With what technologies?

If no, are you aware of any beneficial technologies associated with this activity?

Material Management: ***Yes*** No
If yes, how? With what technologies?

- Typing everything in the database could be improved through some simple scanning tool.
- Work with Vendors and the Warehouse to install scanners to log incoming materials; in some instance there are many small pieces to a project component, this technology would make it easier to track.

If no, are you aware of any beneficial technologies associated with this activity?

Project Controls: Yes ***No***
If yes, how? With what technologies?

If no, are you aware of any beneficial technologies associated with this activity?

Quality Control: ***Yes*** No
If yes, how? With what technologies?

- Some pieces of information are not shared adequately between civil and QC personnel

If no, are you aware of any beneficial technologies associated with this activity?

Safety: Yes ***No***
If yes, how? With what technologies?

- Currently shows safety videos and the weather in the lunchroom - facilitates meetings.

If no, are you aware of any beneficial technologies associated with this activity?

Project Delivery: ***Yes*** No
If yes, how? With what technologies?

- Communication with the client could be improved.

- Could implement a more upfront process; currently company waits until the last second.

If no, are you aware of any beneficial technologies associated with this activity?

Company C – Interview 6

Position: Pipe General Foreman
Industry Experience:
Years of experience in current position – 25 years
Years of experience with current company – 7 years
Years of experience in the industry – 31 years

1. Provided the general scenario:
    a. In which instances would you engage in this process? – Collect information, develop documents

    b. In which instances would you pull that information back for your use? – Specific meetings, inspections
        - Meetings with Pipe Planner to discuss if materials receipt have been postponed.
        - Most meetings occur with Superintendents
        - Meetings with upper management and general foremen

    c. In the survey, you responded that you are _Very Likely__ to take these documents for meetings and inspections. To elaborate on your response, please tell us if you carry around the documents for personal reference/as reference during meetings /as meeting handouts/or distribution?
        - Most meetings occur with superintendents
        - Documents likely to bring: Schedule, Equipment arrival dates, and manpower documents
        - ISO information sheets in conjunction with material availability sheets
        - Pipe Planner updates this information regularly, which is ready for foreman in real-time

    d. Which work documents would you produce in typical week?
        - Mostly spreadsheets, including the spool list—may take the whole day to go through it—, and daily progress updates.

    e. Are these documents provided by your firm, developed by yourself?
        - Documents developed by company are standardized
        - Interviewee updates spool spreadsheets (standardized by company)
        - Interviewee updates E.I. productivity documents daily; helps to understand if foreman are falling behind; this information is updated and readily available in the field so interviewee can have discussions w/ foreman onsite as to why they are falling behind.

2. To what extent do you utilize the software mentioned in the survey (ref survey) to

a. collect and
    - Spreadsheets used to collect information discussed in Question #1.

b. distribute information for these work documents?
    - Spreadsheets used to distribute information discussed in Question #1

3. Are these information technologies being utilized in conjunction with HHC's/Mobile Devices, 3-D Modeling, Misc Info Focal Points (email, Share Drives, BIM), Software, etc.?
    - Use of onsite computers; help provide clarity during daily processes.
    - Also uses phone, e-mail, and text to exchange information. Very useful, especially text messages to communicate amongst foreman when it is very noisy on site. Also, phone used a lot to take pictures onsite.

4. When does the use of the software mentioned help you? (i.e. provide specific information, time benefits, facilitate process, distribute information, etc.) Please mention particular functions that aid your onsite decisions, including meetings and inspections.
    - Onsite - iPIMs & Navisworks to identify ISO's instead of contacting 10 different people is very helpful; also helps organize work to ensure you have all the resources to start an activity
        - More specifically, iPIMs allows you to view the most up to date spool list from the warehouse in real-time; helps general foreman plan and order materials needed for activities, especially helpful when storage space is limited
        - iPIMs with the use of a phone helps find and distribute FCO's
        - Finds the onsite available model one of the most useful and easiest tools to operate—quick reference for a number of items, such as orders and piece's serial numbers
    - Text messages are helpful for communication when there is too much background noise.

5. When does it get in the way? (i.e. difficult to understand/communicate, time consuming, inadequate results, unable to share information, etc.). Please mention particular functions that are inadequate for your purposes.
    - Need additional formal training (when the user does not have the proper knowledge base to use the IT properly or efficiently)
    - Some IT procedural issues go overboard on tracking

6. Based on your current methods (i.e. paper-based, HHC, etc.), what information do you find the most difficult to collect, maintain, and organize onsite?
    - iPIMS - locating standards and specifications

7. Does your current process of developing documents (1d) facilitate communication between stakeholders and allow you to make adequate onsite decisions? Could you provide an example?
    - Yes. Not as much manual inputting of information, current system allows interviewee to fill out information by hand and deliver to a clerk and she inputs it into the system.

8. Do you feel your company could improve the following construction activities/processes with the use of better software or information technologies? (Reference survey, which software they use)

    Design/Specs: Yes ***No***
    If yes, how? With what technologies?

    If no, are you aware of any beneficial technologies associated with this activity?

    Material Management: Yes ***No***
    If yes, how? With what technologies?
    - iPIM's excellent, however, ETA dates for materials could be included in P.O. pages to help with planning. That is, inputting projected dates manually is time consuming.

    If no, are you aware of any beneficial technologies associated with this activity?

    Project Controls: Yes ***No***
    If yes, how? With what technologies?

    If no, are you aware of any beneficial technologies associated with this activity?

    Quality Control: ***Yes*** No
    If yes, how? With what technologies?
    - QC w/ iPads. (ex. clearing welds) could shorten the process by 24 hours—e.g. working on,scanning and sending punchlists could be speeded up.
    - Use iPads to facilitate ISO sign offs which would clear packages faster by allowing the user to e-mail the sign offs to the office faster, which in turn would allow crews to move forward to the next stage of thier activity faster. (sometimes w/ current methods can lose up to a day of waiting because of ISO sign offs.)

    If no, are you aware of any beneficial technologies associated with this activity?

    Safety: Yes ***No***
    If yes, how? With what technologies?

If no, are you aware of any beneficial technologies associated with this activity?

Project Delivery: ***Yes*** No
If yes, how? With what technologies?

- Reference Quality Control

If no, are you aware of any beneficial technologies associated with this activity?

Company C – Interview 7

Position: Controls General Foreman
Industry Experience:
Years of experience in current position – 14 yrs
Years of experience with current company – 7 yrs
Years of experience in the industry – 22 yrs

1. Provided the general scenario:
   a. In which instances would you engage in this process? – Collect information, develop documents

   b. In which instances would you pull that information back for your use? – Specific meetings, inspections
      - Meetings with client, foremen

   c. In the survey, you responded that you are _____ to take these documents for meetings and inspections. To elaborate on your response, please tell us if you carry around the documents for personal reference/as reference during meetings /as meeting handouts/or distribution?
      - Just hand notes from spreadsheets. This spreadsheets automatically feeds from other users.

   d. Which work documents would you produce in typical week?
      - Update certain columns from the tracker spreadsheets to share with superintendents.
      - Notepads and hardcopies of excel spreadsheets taken in the field.
      - The electronic tracker spreadsheets are integrated into other systems and groups information, spread sheet updates progress of other groups relatively automatically and that allows interviewee to know when he can move on to other work and areas of the project. Interviewee delivers this knowledge to the foreman.

   e. Are these documents provided by your firm, developed by yourself?
      - They put together the tracker spreadsheet themselves. Interviewee creates his own spread sheets, but they are moving towards standardizing them.
      - Interviewee continuously updates and tailors spread sheets to project.

2. To what extent do you utilize the software mentioned in the survey (ref survey) to
   a. collect and
   b. distribute information for these work documents?
      - Tracker spreadsheet for update, iPIMSa for accessing RFIs, drawings and specs, also 3D model for accessing information.

- Cloud drawings to communicate with designers and engineers
- Adobe Acrobat Pro - Very useful in creating RFI's on plans and specifications to send to engineer for clarification. Highlight and cloud stuff on drawings.
- Electronic tracker spread sheets very useful to interact with other groups.

3. Are these information technologies being utilized in conjunction with HHC's/Mobile Devices, 3-D Modeling, Misc Info Focal Points (email, Share Drives, BIM), Software, etc.?
    - No. Computers are spread enough on site so that the use of smartphones is not as necessary.

4. When does the use of the software mentioned help you? (i.e. provide specific information, time benefits, facilitate process, distribute information, etc.) Please mention particular functions that aid your onsite decisions, including meetings and inspections.
    - Cloud drawings to communicate with designers and engineers, as opposed to manually scanning and marking the document.
    - Tracker spreadsheet has reduced the interaction time with other groups, as only specific questions are a basis to contact each other.
    - The 3D model enables coordination with other stakeholders, and also building stuff quicker because it is easier to figure out where components will be installed before having them physically on site.
    - iPIMs - Accessing RFI's, drawings, material/equipment information quickly

5. When does it get in the way? (i.e. difficult to understand/communicate, time consuming, inadequate results, unable to share information, etc.). Please mention particular functions that are inadequate for your purposes.
    - May be interrupting, when there is too much input—for instance, from the phone.

6. Based on your current methods (i.e. paper-based, HHC, etc.), what information do you find the most difficult to collect, maintain, and organize onsite?
    - Datasheets and specs in iPIMS are not standardly described.
    - iPIMs - Locating 3rd Party Vendor information

7. Does your current process of developing documents (1d) facilitate communication between stakeholders and allow you to make adequate onsite decisions? Could you provide an example?
    - Mostly yes.

8. Do you feel your company could improve the following construction activities/processes with the use of better software or information technologies? (Reference survey, which software they use)

Design/Specs: Yes ***No***
If yes, how? With what technologies?

If no, are you aware of any beneficial technologies associated with this activity?

Material Management: Yes ***No***
If yes, how? With what technologies?
If no, are you aware of any beneficial technologies associated with this activity?

Project Controls: Yes ***No***
If yes, how? With what technologies?

If no, are you aware of any beneficial technologies associated with this activity?

Quality Control: Yes ***No***
If yes, how? With what technologies?

If no, are you aware of any beneficial technologies associated with this activity?

Safety: Yes ***No***
If yes, how? With what technologies?

If no, are you aware of any beneficial technologies associated with this activity?

Project Delivery: Yes ***No***
If yes, how? With what technologies?

If no, are you aware of any beneficial technologies associated with this activity?

Company C – Interview 8

Position: Civil General Foreman
Industry Experience:
Years of experience in current position – 5 years as General Foreman, 16 years in Supervision
Years of experience with current company –22 years – all industrial construction
Years of experience in the industry –

1. Provided the general scenario:
   a. In which instances would you engage in this process? – Collect information, develop documents

   b. In which instances would you pull that information back for your use? – Specific meetings, inspections
      - Meetings with Foremen, with Superintendents, Field Inspections
      - Uses iPIMs to track quantities
      - Uses E-mails for Weekly Meetings

   c. In the survey, you responded that you are _____ to take these documents for meetings and inspections. To elaborate on your response, please tell us if you carry around the documents for personal reference/as reference during meetings /as meeting handouts/or distribution?
      - Logs from iPIMS for each meeting; redistribution of safety emails
      - Uses Pour slips provided by foreman

   d. Which work documents would you produce in typical week?
      - Safety Task Analysis sign off (yardage, blueprints, tools, equipment, concrete quantities)
      - Concrete spreadsheet, to know which foundations will be poured, volume (quantity) of concrete.

   e. Are these documents provided by your firm, developed by yourself?
      - Mostly standard documents

2. To what extent do you utilize the software mentioned in the survey (ref survey) to
   a. collect and
   b. distribute information for these work documents?
      - To a minimum, most paperwork is done by foremen

3. Are these information technologies being utilized in conjunction with HHC's/Mobile Devices, 3-D Modeling, Misc Info Focal Points (email, Share Drives, BIM), Software, etc.?
    - No. There are computers in the field offices though.

4. When does the use of the software mentioned help you? (i.e. provide specific information, time benefits, facilitate process, distribute information, etc.) Please mention particular functions that aid your onsite decisions, including meetings and inspections.
    - iPIMS is useful
    - Use of internet connections to access MSDS for a liquid/epoxy, looking at the weather, being able to get prints without depending on clerks and have access to modifications and changes
    - 3D Model facilitates looking at components, making decisions, can check revisions to plans in real-time, on other jobs has been helpful for reviewing potential clashes of trades or facility component clashes.

5. When does it get in the way? (i.e. difficult to understand/communicate, time consuming, inadequate results, unable to share information, etc.). Please mention particular functions that are inadequate for your purposes.
    - No particular instances

6. Based on your current methods (i.e. paper-based, HHC, etc.), what information do you find the most difficult to collect, maintain, and organize onsite?
    - In general, the information that needs to be accessed through the computer, whether emails, plans, spreadsheets, is difficult to obtain because there is no training for the use of computers.
    - Sending prints to the warehouse; would be helpful to have a clerk.

7. Does your current process of developing documents (1d) facilitate communication between stakeholders and allow you to make adequate onsite decisions? Could you provide an example?
    - Yes, the process is sufficient.

8. Do you feel your company could improve the following construction activities/processes with the use of better software or information technologies? (Reference survey, which software they use)

    Design/Specs: ***Yes*** No
    If yes, how? With what technologies?
    - Having access to the model in the field could provide a better understanding of construction processes. and being able to make revisions with the use of electronic plans.

If no, are you aware of any beneficial technologies associated with this activity?

Material Management: Yes ***No***
If yes, how? With what technologies?

If no, are you aware of any beneficial technologies associated with this activity?

Project Controls: Yes ***No***
If yes, how? With what technologies?

If no, are you aware of any beneficial technologies associated with this activity?

Quality Control: ***Yes*** No
If yes, how? With what technologies?

- Corner bars are not drawn as they will be installed because otherwise they cannot be seen. QC personnel with a background in civil construction are needed. More readily available 3D model in the field would be helpful.

If no, are you aware of any beneficial technologies associated with this activity?

Safety: Yes ***No***
If yes, how? With what technologies?

If no, are you aware of any beneficial technologies associated with this activity?

Project Delivery: Yes ***No***
If yes, how? With what technologies?
If no, are you aware of any beneficial technologies associated with this activity?

Company C – Participant 9

Position: Electrical Superintendent
Industry Experience:
Years of experience in current position – 3 yrs
Years of experience with current company – 17 yrs
Years of experience in the industry – 32 yrs

1. Provided the general scenario:
    a. In which instances would you engage in this process? – Collect information, develop documents

    b. In which instances would you pull that information back for your use? – Specific meetings, inspections
        - Meetings with superintendents, General Foremen, Inspections
        - Spread sheet

    c. In the survey, you responded that you are _____ to take these documents for meetings and inspections. To elaborate on your response, please tell us if you carry around the documents for personal reference/as reference during meetings /as meeting handouts/or distribution?
        - Bring printouts to meetings mostly for reference.
        - Tracking spreadsheets used to communicate with General Foremen, cost department.
        - (Ex. Spread sheets for tracking equipment for audits and spread sheets for tracking progress.)

    d. Which work documents would you produce in typical week?
    Spreadsheets to track loop sales, QC, issues. Same spreadsheet that is used by the technical services personnel (TSM).
        - Access to iPIMS logs, drawings, email.

    e. Are these documents provided by your firm, developed by yourself?
        - Mostly developed with TSM, such as: the tracking spreadsheet; the assessment turnover document, which indicates when loop checks can be started; spreadsheets to track equipment and audits.
        - in the field will input information; following will print out information for meetings; send information by TSM to client (only sends some information, not all of it).

2. To what extent do you utilize the software mentioned in the survey (ref survey) to
    a. collect and
    b. distribute information for these work documents?
        - Mostly, General Foremen view documents in iPIMS with field computers.

3. Are these information technologies being utilized in conjunction with HHC's/Mobile Devices, 3-D Modeling, Misc Info Focal Points (email, Share Drives, BIM), Software, etc.?
        - Typically, no.
        - Uses iPhone for pictures for QC

4. When does the use of the software mentioned help you? (i.e. provide specific information, time benefits, facilitate process, distribute information, etc.) Please mention particular functions that aid your onsite decisions, including meetings and inspections.
        - **No examples.**
        - iPIM's to review updated drawings.

5. When does it get in the way? (i.e. difficult to understand/communicate, time consuming, inadequate results, unable to share information, etc.). Please mention particular functions that are inadequate for your purposes.
        - More than one source for the same piece of information complicates access.
        - Losing connection to servers shuts down access to documents.

6. Based on your current methods (i.e. paper-based, HHC, etc.), what information do you find the most difficult to collect, maintain, and organize onsite?
        - No, since he's experienced enough to know where things are.
            - Systems are not friendly for new superintendents.

7. Does your current process of developing documents (1d) facilitate communication between stakeholders and allow you to make adequate onsite decisions? Could you provide an example?
        - Safety issues need to be person-to-person, and so do critical tasks, in order to get appropriate feedback.

8. Do you feel your company could improve the following construction activities/processes with the use of better software or information technologies? (Reference survey, which software they use)

    Design/Specs: ***Yes*** No
    If yes, how? With what technologies?

- Touchpads could be useful in couple with the model & for accessing contracts.

If no, are you aware of any beneficial technologies associated with this activity?

Material Management: ***Yes*** No
If yes, how? With what technologies?

- Touchpads could be useful for material requests

If no, are you aware of any beneficial technologies associated with this activity?

Project Controls: ***Yes*** No
If yes, how? With what technologies?

- Touchpads could be useful to fill out time sheets in the field, as it is a lengthy process by hand. It would also be useful to fill out audit spreadsheets in the field on PMM.

If no, are you aware of any beneficial technologies associated with this activity?

Quality Control: Yes ***No***
If yes, how? With what technologies?

If no, are you aware of any beneficial technologies associated with this activity?

Safety: Yes ***No***
If yes, how? With what technologies?

If no, are you aware of any beneficial technologies associated with this activity?

Project Delivery: Yes ***No***
If yes, how? With what technologies?

If no, are you aware of any beneficial technologies associated with this activity?

- No, system turnover documentation is enough.

Company D – Interview 1

Position: Structural Superintendent
Industry Experience:
Years of experience in current position – 8 yrs
Years of experience with current company – 22 yrs
Years of experience in the industry –28 yrs (Only power division industry)

1. Provided the general scenario:
    a. In which instances would you engage in this process? – Collect information, develop documents
        - Mostly uses e-mail for communication
        - Reviewing/developing personnel safety task assessments w/ general foreman and their associated workforce groups.

    b. In which instances would you pull that information back for your use? – Specific meetings, inspections
        - Use safety data during meetings in the A.M. w/ General Foreman ("toolbox talks"); Assort and assign tasks for the day. General Foreman have STA meetings with their work groups.
        - During STA Meetings a safety sheet is filled out; provided to safety team and safety team compiles information and produces and provides trends for reports back to the field.

    c. In the survey, you responded that you are __Very Likely_ to take these documents for meetings and inspections. To elaborate on your response, please tell us if you carry around the documents for personal reference/as reference during meetings /as meeting handouts/or distribution?
        - Reference above (b.)
        - Foreman fills out safety information and hands over to superintendent.
        - Brings cost and schedule reports to meetings with the foreman (only in the office...never brings this information to the field)

    d. Which work documents would you produce in typical week?
        - Schedule - communicates activities and their durations (ex. build boiler) to scheduler to produce: "3-week look-ahead" and a "90-day look-ahead". Typically face-to-face.
        - Cost/Estimate Info - Delivers cost information to estimator/planner (ex. tonnage/man hr.) typically face-to-face or via e-mail.

    e. Are these documents provided by your firm, developed by yourself?
        - Documents are completely standardized (Schedules, safety reports, cost reports, etc.)

2. To what extent do you utilize the software mentioned in the survey (ref survey) to
    a. collect and
    b. distribute information for these work documents?
        - Uses e-mail to communicate to vendors, PM's; mostly used for internal communications.
        - Mobile smart phone used to develop and receive e-mails. (about 10 e-mails per day)
        - Rarely uses any other electrical devices/software to collect or distribute information. Mostly paper-based. Receives electronic information via e-mail occasionally.

3. Are these information technologies being utilized in conjunction with HHC's/Mobile Devices, 3-D Modeling, Misc Info Focal Points (email, Share Drives, BIM), Software, etc.?
    - e-mail used in conjunction w/ smart phone
    - cannot open electronic documents on his phone.

4. When does the use of the software mentioned help you? (i.e. provide specific information, time benefits, facilitate process, distribute information, etc.) Please mention particular functions that aid your onsite decisions, including meetings and inspections.
    - IT has helped. - E-mail and Phone
    - Supports better communication and helps receive information quicker.

5. When does it get in the way? (i.e. difficult to understand/communicate, time consuming, inadequate results, unable to share information, etc.). Please mention particular functions that are inadequate for your purposes.
    - No. IT has not been time consuming.
    - Tablets were implemented for tracking progress but they were not sturdy enough.

6. Based on your current methods (i.e. paper-based, HHC, etc.), what information do you find the most difficult to collect, maintain, and organize onsite?
    - None.

7. Does your current process of developing documents (1d) facilitate communication between stakeholders and allow you to make adequate onsite decisions? Could you provide an example?
    - Finds paper-based documentation too be excessive. Less documents could be better.
    - Provided paper-based costs every 3-4 days; unnecessary.
    - Could be better if he could simply access this information electronically.

8. Do you feel your company could improve the following construction activities/processes with the use of better software or information technologies? (Reference survey, which software they use)

Design/Specs: Yes ***No***
If yes, how? With what technologies?

- Was tracking progress of drawings in the field but did not find tablets sturdy enough and didn't find useful.

If no, are you aware of any beneficial technologies associated with this activity?

Material Management: Yes ***No***
If yes, how? With what technologies?

If no, are you aware of any beneficial technologies associated with this activity?

Project Controls: Yes ***No***
If yes, how? With what technologies?

If no, are you aware of any beneficial technologies associated with this activity?

Quality Control: Yes ***No***
If yes, how? With what technologies?

- There is a separate QC department, comes out and takes pictures when there is damaged equipment

If no, are you aware of any beneficial technologies associated with this activity?

Safety: Yes ***No***
If yes, how? With what technologies?

If no, are you aware of any beneficial technologies associated with this activity?

Project Delivery: Yes ***No***
If yes, how? With what technologies?

If no, are you aware of any beneficial technologies associated with this activity?

Company D - Interview 2

Position: Civil Superintendent
Industry Experience:
Years of experience in current position – 38 yrs
Years of experience with current company – 25 yrs (on and off)
Years of experience in the industry – 18 yrs

1. Provided the general scenario:
    a. In which instances would you engage in this process? – Collect information, develop documents
        - Responsible for excavation, formwork, rebar, concrete, backfill, etc.
        - STA (Safety Task Assessments) in the morning - Has 50 employees (Carpenters, laborers, reinforcing steel workers) working under him. Provides them a general briefing and then they break out into their respective task specific groups to discuss STA info.
        - Following STA meetings goes in office and reviews daily reports from previous days against time sheets, cost sheets, and material quantities collected.

    b. In which instances would you pull that information back for your use? – Specific meetings, inspections
        - Foreman has drawings (pages & pages) - Paper-Based
        - STA information distributed to safety personnel and received compiled information and trends
        - Document Control - Fills out sheets on how many foreman are under him and receives drawing for that number of foreman.
        - Changes made to the drawings are performed and updated by engineers offsite. Often takes days to receive that information. When a field change wants to be made a paper-based memo has to be created in the field...can take a little while for the memo to go through the process. Field engineer will create paper-based memo to allow the continuation of work if project team runs into a problem in the field.

    c. In the survey, you responded that you are _____ to take these documents for meetings and inspections. To elaborate on your response, please tell us if you carry around the documents for personal reference/as reference during meetings /as meeting handouts/or distribution?
        - Superintendent meeting w/ PM everyday to review and analyze synchronization of schedules.
        - Talks to planner to develop and update schedule during schedule review meetings.

- Contacts facilitator w/ look-heads (paper-based) so he can prepare and get materials necessary for future tasks.

d. Which work documents would you produce in typical week?
   - Receives/distributes 15-20 e-mails per day.
   - Utilizes notepad to jot down notes/conversations in the field so he can type them out back at the office.
   - Reviews document control list electronically
   - Develops spreadsheets to track information (ex. cost data, manpower); updated weekly or monthly.

e. Are these documents provided by your firm, developed by yourself?
   - Standard Zachry documents always used.

2. To what extent do you utilize the software mentioned in the survey (ref survey) to
   a. collect and
   b. distribute information for these work documents?
      - N/A

3. Are these information technologies being utilized in conjunction with HHC's/Mobile Devices, 3-D Modeling, Misc Info Focal Points (email, Share Drives, BIM), Software, etc.?
   - Uses phone (blackberry) - used for e-mails
   - Can access email attachments such as drawings and spreadsheets via his phone.

4. When does the use of the software mentioned help you? (i.e. provide specific information, time benefits, facilitate process, distribute information, etc.) Please mention particular functions that aid your onsite decisions, including meetings and inspections.
   - "It would be impossible to do the work they do w/ out computers."
   - To be able to go back to e-mails to reference information.
   - Access safety data received from safety via computer occasionally
   - Access material & equipment information on internet.

5. When does it get in the way? (i.e. difficult to understand/communicate, time consuming, inadequate results, unable to share information, etc.). Please mention particular functions that are inadequate for your purposes.
   - People e-mailing instead of face to face communications. Sometimes it is necessary to have eye contact to assess mental and physical fitness of workers.

6. Based on your current methods (i.e. paper-based, HHC, etc.), what information do you find the most difficult to collect, maintain, and organize onsite?
    - Nothing specific
    - The use of computers could induce faster processes; need information instantly sometimes but it is all paper-based so it takes longer than desired.
    - Certain information cannot be accessed by superintendents but document control releases that information—it can be slow to obtain revisions.

7. Does your current process of developing documents (1d) facilitate communication between stakeholders and allow you to make adequate onsite decisions? Could you provide an example?
    - Has a difficult time keeping up w/ technology.
    - Sometimes too many documents (because of updates and changes) are found in the field.

8. Do you feel your company could improve the following construction activities/processes with the use of better software or information technologies? (Reference survey, which software they use)

    Design/Specs: Yes ***No***
    If yes, how? With what technologies?

    If no, are you aware of any beneficial technologies associated with this activity?

    Material Management: Yes ***No***
    If yes, how? With what technologies?

    If no, are you aware of any beneficial technologies associated with this activity?

    Project Controls: Yes ***No***
    If yes, how? With what technologies?

    If no, are you aware of any beneficial technologies associated with this activity?

    Quality Control: Yes ***No***
    If yes, how? With what technologies?

    If no, are you aware of any beneficial technologies associated with this activity?
    - Paper-based manuals are available.

    Safety: Yes ***No***
    If yes, how? With what technologies?

If no, are you aware of any beneficial technologies associated with this activity?

- Database already provides access to subcontractors' daily records.

Project Delivery: Yes ***No***
If yes, how? With what technologies?

If no, are you aware of any beneficial technologies associated with this activity?

Company D – Interview 3

Position: Foreman
Industry Experience:
Years of experience in current position – 6
Years of experience with current company – 12
Years of experience in the industry – 18

1. Provided the general scenario:
   a. In which instances would you engage in this process? – Collect information, develop documents

   b. In which instances would you pull that information back for your use? – Specific meetings, inspections
      - Meetings with crew, meetings with general foreman.

   c. In the survey, you responded that you are Very Unlikely to take these documents for meetings and inspections. To elaborate on your response, please tell us if you carry around the documents for personal reference/as reference during meetings /as meeting handouts/or distribution?
      - Just access printed documents in the field

   d. Which work documents would you produce in typical week?
      - Safety task assessments, foreman daily reports, time sheets, safety sign-in sheets, job observations for safety. All are handwritten.

   e. Are these documents provided by your firm, developed by yourself?
      - All are firm's forms

2. To what extent do you utilize the software mentioned in the survey (ref survey) to
   a. collect and
   b. distribute information for these work documents?
      - Does not use computers, nor does he have an email account.

3. Are these information technologies being utilized in conjunction with HHC's/Mobile Devices, 3-D Modeling, Misc Info Focal Points (email, Share Drives, BIM), Software, etc.
      - No phone access in the field.

4. When does the use of the software mentioned help you? (i.e. provide specific information, time benefits, facilitate process, distribute information, etc.) Please mention particular functions that aid your onsite decisions, including meetings and inspections.

- Phone aids communication with superintendents, as opposed to not having a phone to talk to the crews

5. When does it get in the way? (i.e. difficult to understand/communicate, time consuming, inadequate results, unable to share information, etc.). Please mention particular functions that are inadequate for your purposes.
    - Phones can be a distraction, for instance, when taking personal calls.

6. Based on your current methods (i.e. paper-based, HHC, etc.), what information do you find the most difficult to collect, maintain, and organize onsite?
    - Sometimes it is difficult to access drawings.

7. Does your current process of developing documents (1d) facilitate communication between stakeholders and allow you to make adequate onsite decisions? Could you provide an example?
    - Too much paperwork.

8. Do you feel your company could improve the following construction activities/processes with the use of better software or information technologies? (Reference survey, which software they use)

    Design/Specs: ***Yes*** No
    If yes, how? With what technologies?
    - Reminders to help you plan the work ahead could help.

    If no, are you aware of any beneficial technologies associated with this activity?

    Material Management: ***Yes*** No
    If yes, how? With what technologies?
    - Databases can help to dramatically reduce the time to access information. In particular, to locate materials.

    If no, are you aware of any beneficial technologies associated with this activity?

    Project Controls: ***Yes*** No
    If yes, how? With what technologies?
    If no, are you aware of any beneficial technologies associated with this activity?

    Quality Control: ***Yes*** No
    If yes, how? With what technologies?
    - Provide access to work procedures, for instance, welding.

    If no, are you aware of any beneficial technologies associated with this activity?

Safety: ***Yes*** No
If yes, how? With what technologies?

- Access to safety references, such as MSDS or safety standards.

If no, are you aware of any beneficial technologies associated with this activity?

Project Delivery: Yes ***No***
If yes, how? With what technologies?

If no, are you aware of any beneficial technologies associated with this activity?

Company D – Interview 4

Position: Piping Superintendent
Industry Experience:
Years of experience in current position – 14
Years of experience with current company – 13
Years of experience in the industry – 30

1. Provided the general scenario:
   a. In which instances would you engage in this process? – Collect information, develop documents

   b. In which instances would you pull that information back for your use? – Specific meetings, inspections
      - Meetings with general foremen, with crews for planning.

   c. In the survey, you responded that you are _____ to take these documents for meetings and inspections. To elaborate on your response, please tell us if you carry around the documents for personal reference/as reference during meetings /as meeting handouts/or distribution?
      - Likely. Use of isometric drawings, screenshots from 3D model whenever issues come up.
      - Use of schedules and cost reports when meeting General Foremen.

   d. Which work documents would you produce in typical week?
      - 3wk look-ahead and 90 day schedule.

   e. Are these documents provided by your firm, developed by yourself?
      - These are standard documents.

2. To what extent do you utilize the software mentioned in the survey (ref survey) to
   a. collect and
   b. distribute information for these work documents?
      - Some distribution done through screenshots of the models and schedules.

3. Are these information technologies being utilized in conjunction with HHC's/Mobile Devices, 3-D Modeling, Misc Info Focal Points (email, Share Drives, BIM), Software, etc.?
   - Just phone and radio

4. When does the use of the software mentioned help you? (i.e. provide specific information, time benefits, facilitate process, distribute information, etc.) Please

mention particular functions that aid your onsite decisions, including meetings and inspections.

- "It's getting easier" to perform work. More accurate drawings and improved communication.

5. When does it get in the way? (i.e. difficult to understand/communicate, time consuming, inadequate results, unable to share information, etc.). Please mention particular functions that are inadequate for your purposes.
    - Typing can be a hassle. Didn't grow up typing.

6. Based on your current methods (i.e. paper-based, HHC, etc.), what information do you find the most difficult to collect, maintain, and organize onsite?
    - Information is mostly available, either through computers or planners (people).

7. Does your current process of developing documents (1d) facilitate communication between stakeholders and allow you to make adequate onsite decisions? Could you provide an example?
    - Yes. Not too many documents to develop on his part. Perhaps from the standpoint of foremen.

8. Do you feel your company could improve the following construction activities/processes with the use of better software or information technologies? (Reference survey, which software they use)

    Design/Specs: Yes ***No***
    If yes, how? With what technologies?

    If no, are you aware of any beneficial technologies associated with this activity?

    Material Management: Yes ***No***
    If yes, how? With what technologies?
    - There's someone in the yard making sure materials are available.

    If no, are you aware of any beneficial technologies associated with this activity?

    Project Controls: Yes ***No***
    If yes, how? With what technologies?

    If no, are you aware of any beneficial technologies associated with this activity?

    Quality Control: Yes ***No***
    If yes, how? With what technologies?

If no, are you aware of any beneficial technologies associated with this activity?

Safety: Yes ***No***
If yes, how? With what technologies?

If no, are you aware of any beneficial technologies associated with this activity?

Project Delivery: Yes ***No***
If yes, how? With what technologies?

If no, are you aware of any beneficial technologies associated with this activity?

Appendix C: IT Training and Evaluation Exercise

C.1 Training Scenarios

No. 1 - "Design Changes" - Identify a new or recent in-field design change made during a job site activity. Utilize the redlining software along with the available 2D/3D drawings to provide clarification for the basis for the design changes. Utilizing the software tools, provide a moderately detailed recommended design change for approval by the engineer.

Step 1) Locate PDF Page 5/20 - "Page 5 - Farmington Avenue Plan and Profile (3 of 5)"

Step 2) Locate the **6" hydrant** at **Station 11+ 28**.

Step 3) Show a recommended design change with the use of the "mark-up tools"; **recommend shifting the hydrant West** (to the right - North Arrow is facing downward) **approximately 8 feet** (**Recommended Tools:** Redlining Tool, Linear Measurement Indicator, Highlighter)

Step 4) Provide clarification to the design change by adding the comment: **"Shift 6 in. hydrant tee 8 feet West to Station 11+36. Reduces likelihood of stagnant water during chlorination. Ensure enough space is left for installation of 2" Sterilization Blowoff."**

Step 5) **Highlight** your design change as you see fit to ensure the comment is not overlooked. (**Recommended Tools:** Highlighter, Cloud)

No. 2 - "RFI Clarification" - Identify a new or recently recorded RFI for a jobsite activity. Utilize the redlining software to attach the RFI to the set of 2D/3D available drawings. In addition, use the markup/comments tool to provide further clarification for the RFI.

Step 1) Locate PDF Page 3/20 - "Page 3 - Farmington Avenue Plan and Profile (1 of 5)"

Step 2) Locate the **20" Line Stops** at **Station 0+00**.

Step 3) **Utilize an RFI Template.** Have the RFI read, **"Please provide clarification as to the significance of tuberculation in the existing 20" pipes. Will the level of tuberculation hinder the installation of the line stops? If so, please advise a design change."**

Step 4) **Locate and highlight** all **three Line Stops** in the designated area in the plan view to provide clarification. Use the software tools as you see fit. (**Recommended Tools:** Redlining tool, Highlighter, Cloud)

Step 5) **Attach a photo or "snapshot"** of the 2D drawings to the RFI.

Step 6) **E-mail the RFI** to your current e-mail address or attach it to the electronic drawing set.

No. 3 - "Inserting/Attaching Pictures" - Locate a new or recently completed jobsite activity. Utilize the redlining software to attach a photo to the drawing set to provide further clarification to a QA/QC or as-built scenario.

Step 1) Locate PDF Page 4/20 - "Page 4 - Farmington Avenue Plan and Profile (2 of 5)"

Step 2) Locate the **Test Pit** at **Station 7+20**.

Step 3) Using the software, **take a photo of your current construction environment** (this will serve as a "mock photo" for this scenario).

Step 4) **Attach the photo or a link** to the photo above the test pit call out.

Step 5) **Use the comment tools** to provide further clarification, **"Test Pit 7+20 performed; no utility conflicts anticipated."**

No. 4 - "As-Built Sketches & Notes" - Locate a new or recently completed jobsite activity. Utilize redlining software to add as-built information electronically to the 2D/3D available drawings including but not limited to as-built elevations, measurements, installation date and valuable installation or maintenance information. Deliver the as-built plans electronically to additional field personnel via an online database or e-mail.

Step 1) Locate PDF Page 6/20 - "Page 6 - Farmington Avenue Plan and Profile (4 of 5)"

Step 2) **Locate the 4" Fire Service** at **Station 16+10**.

Step 3) **Highlight** the Fire Service (**Recommended Tools:** Highlighter, Cloud)

Step 4) **Use the redlining tools to add As-Built information**, including:

A.) **Redraw the layout of the 4" Fire Service.** Use the redlining tools to Shift the **4" Fire Service Tee** to the West 5' to **Station 16+15** (does not need to be exact) and have the new layout of the **4" pipe meet the originally designed connection point (Hint:** Add bends to the pipe**)**. (**Recommended Tools:** Redlining, Linear Measurement Tool, Highlighter)

Step 5) **Use the comment tools** to provide clarity to your mark-ups, including:

A) "As-Built Installation Station for 24" x 4" FS Tee - **Station 16+15**, 2' North of Farmington South Curb"
B.) Call out any bends included in the 4" pipe layout
C.) "Fire Service Tee Elevation - 92.46' NAVD88"

No. 5 - "Locate Design Information" - Identify and utilize the available 2D/3D drawings to locate design and detail information for an ongoing jobsite activity. Concentration on the software's navigation tool capabilities. If possible, create a link between the details required for the chosen activity and plan set required for the chosen activity.

Step 1) Locate PDF Page 6/20 - "Page 6 - Farmington Avenue Plan and Profile (4 of 5)"

Step 2) On Page 6, locate **Station 15+00**. This 16" pipe has restrained joints.

Step 3) A link to a "Typical Restrained Joints" detail has been created for this pipe. **Click on the link to ensure it is functional.** This should take you directly to the detail. (These types of links can be created on the desktop version of the software for quick plan set navigation in the field.)

No. 6 - "Locate Old Comments/Mark-ups" - Reference back to all comments and mark-ups you've incorporated into the plans from the previous scenarios. Try to use the software's tools to make this process more efficient.

Step 1) **Reference Library of Comments and Markups**

Step 2) **Sift through all comments and mark-ups** developed within this trial.

C.2 Technology Evaluation Sheet

Date: Company: Location: User #: Software:

Software Evaluation Sheet

Q1: How many years experience do you have in the industry? ☐

Q2: What is your current position? ☐

Q3: What is your experience level with tablet devices from 1 to 5 (Circle Answer)?
1 = Little/No Experience & 5 = High Level/Expert Experience

1 2 3 4 5

Q4: On average, how often do you utilize and mark-up drawing sets on a daily basis (Circle Answer)?

Less than once 1-3 4-6 More than 6 times

Q5: Is a Stylus or Electronic Pen being utilized for this trial? (Circle Answer) YES NO

Fill in the tables below. The "Level of Importance" column indicates your opinion on how important that particular functionality or activity is in relation to your daily tasks; please indicate a low, medium or high level of importance. Use the Likert Scale (shown above each table) to rate the Information Technology's functionality in comparison to traditional paper-based methods:

1.) Field Trial 1 - Visibility

Task/Activity	Level of Importance (L/M/H)	Red-Lining IT Tool Compared to Traditional Paper Based Methods (Likert Scale 1-6)	Additional Comments
Effectively View Drawings - Field of View Constraints (i.e. Screen Size vs. Traditional 24" x 36" Drawing Sets)			
Visibility of Drawing Set Given Onsite Environment (i.e. Direct Sunlight)			
Recommendations for Improvements:			

2.) Field Trial 1 - Mobility

Task/Activity	Level of Importance (L/M/H)	Red-Lining IT Tool Compared to Traditional Paper Based Methods (Likert Scale 1-6)	Additional Comments
Mobility of Drawing Sets Around in the Field (i.e. Carrying Mobile Device vs. Traditional Drawing Sets)			
Recommendations for Improvements:			

3.) Field Trial 1 - Communication

Task/Activity	Level of Importance (L/M/H)	Red-Lining IT Tool Compared to Traditional Paper Based Methods (Likert Scale 1-6)			Additional Comments
		Time Spent Completing the Tasks	Simplicity of Completing the Task	Ability to Effectively Complete the Task	
Clarity/Distribution of Design Changes and As-Built Drawings with Comments, Mark-ups and etc.					
Clarity/Distribution of RFI's w/ the Use of Plans and Specs					
Access, Distribute and Maintain the Most To-Date Version of Drawing Sets					
Ability to Recall "Old" Mark-ups/Comments for Reference During Formal/Informal Meetings					
Recommendations for Improvements:					

4.) Field Trial 1 - IT Functionality

Task/Activity	Level of Importance (L/M/H)	Red-Lining IT Tool Compared to Traditional Paper Based Methods (Likert Scale 1-6)			Additional Comments
		Time Spent Completing the Tasks	Simplicity of Completing the Task	Ability to Effectively Complete the Task	
Ability to Redline and Effectively Mark-up/Highlight Items in Drawing Sets/Specifications					
Ability to Attach Comments to Drawing Sets/Specifications					
Ability to Define and Attach As-Built Information					
Alter/Remove Redlines and Comments in Drawing Sets/Specifications					
Ability to Sift Through and Locate Mark-ups/Highlighted Items for Drawings Sets/Specifications					
Ability to Sift Through and Locate Comments for Drawing Sets/Specifications					
Provide Robust Clarity to Comments and Mark-ups (i.e. Attach Pictures)					
Ability to Create, Attach and Link RFI's w/ the Use of Plans and Specs					
Maintaining the Most To-Date Version of Drawing Sets and Specifications					
Navigation of Drawing Set - Page to Page (i.e. Search Drawing Set, Scrolling from Drawing to Drawing)					
Navigation of Drawing Set - Amongst Pages, Details, and Specifications (i.e. Locating details specific to a plan set)					
Navigation of Drawings - Single Page (i.e. Scrolling through a Drawing, Zooming In and Out)					
Recommendations for Improvements:					

Follow-Up Questions:

1.) Would you provide/perform drawing revisions and updates at a higher frequency with the use of the IT tool? (Y/N)

2.)Please, provide some features you would like to see incorporated into the IT tool used (improvements to IT tool)?

3.) Do you feel there would be a measurable improvement in time savings due to the implementation of the IT tool? If yes, which alternative activities would this free up time for? If no, why not?

4.) Were there any specific major time losses caused by the use of the IT tool? What caused the time losses?

5.) How well did the IT tool fit into your current way of executing work? Did it require you to perform any extra steps or adjust your typical activities to use the software?

6.) Did it act as a sufficient or improved replacement for paper-based drawing sets?

7.) Was there any information you were not able to readily collect with the use of the IT tool that you normally capture with the use of standard hardcopy drawings and specs?

8.) Would you recommend the implementation of the IT tool full-time? (Y/N) Why?

C.3 IT Training and Evaluation Study Results - Raw Data

Date: 09/19/2013 Company: [redacted] Location: San Antonio, Tx User #: Software: [redacted]

Software Evaluation Sheet

Q1: How many years experience do you have in the industry? 25

Q2: What is your current position? Business Unit Manager

Q3: What is your experience level with tablet devices from 1 to 5 (Circle Answer)?
1 = Little/No Experience & 5 = High Level/Expert Experience

1 2 3 4 (5)

Q4: On average, how often do you utilize and mark-up drawing sets on a daily basis (Circle Answer)?

Less than once (1-3) 4-6 More than 6 times

Q5: Is a Stylus or Electronic Pen being utilized for this trial? (Circle Answer) YES (NO)

Fill in the tables below. The "Level of Importance" column indicates your opinion on how important that particular functionality or activity is in relation to your daily tasks; please indicate a low, medium or high level of importance. Use the Likert Scale (shown above each table) to rate the Information Technology's functionality in comparison to traditional paper-based methods:

1.) Field Trial 1 - Visibility

Task/Activity	Level of Importance (L/M/H)	Red-Lining IT Tool Compared to Traditional Paper Based Methods (Likert Scale 1-6)	Additional Comments
Effectively View Drawings - Field of View Constraints (i.e. Screen Size vs. Traditional 24" x 36" Drawing Sets)	H	6	Prefer to have electronic files for viewing and markup.
Visibility of Drawing Set Given Onsite Environment (i.e. Direct Sunlight)	H	5	
Recommendations for Improvements:			

2.) Field Trial 1 - Mobility

Task/Activity	Level of Importance (L/M/H)	Red-Lining IT Tool Compared to Traditional Paper Based Methods (Likert Scale 1-6)	Additional Comments
Mobility of Drawing Sets Around in the Field (i.e. Carrying Mobile Device vs. Traditional Drawing Sets)	H	6	HAVING ACCESS TO THE ELECTRONIC FILES IS FASTER SEARCHING DOCUMENTS AND ENSURING THAT THE DOCUMENTS ARE ALWAYS UPDATED
Recommendations for Improvements:			

3.) Field Trial 1 - Communication

Task/Activity	Level of Importance (L/M/H)	Red-Lining IT Tool Compared to Traditional Paper Based Methods (Likert Scale 1-6)			Additional Comments
		Time Spent Completing the Tasks	Simplicity of Completing the Task	Ability to Effectively Complete the Task	
Clarity/Distribution of Design Changes and As-Built Drawings with Comments, Mark-ups and etc.	H	6	6	6	
Clarity/Distribution of RFI's w/ the Use of Plans and Specs	H	6	6	6	
Access, Distribute and Maintain the Most To-Date Version of Drawing Sets	H	6	6	6	
Ability to Recall "Old" Mark-ups/Comments for Reference During Formal/Informal Meetings	H	6	6	6	
Recommendations for Improvements:					

4.) Field Trial 1 - IT Functionality

Task/Activity	Level of Importance (L/M/H)	Red-Lining IT Tool Compared to Traditional Paper Based Methods (Likert Scale 1-6)			Additional Comments
		Time Spent Completing the Tasks	Simplicity of Completing the Task	Ability to Effectively Complete the Task	
Ability to Redline and Effectively Mark-up/Highlight Items in Drawing Sets/Specifications	H	6	6	6	
Ability to Attach Comments to Drawing Sets/Specifications	H	6	6	6	
Ability to Define and Attach As-Built Information	H	6	6	6	
Alter/Remove Redlines and Comments in Drawing Sets/Specifications	M	5	4	5	
Ability to Sift Through and Locate Mark-ups/Highlighted Items for Drawings Sets/Specifications	H	6	6	6	
Ability to Sift Through and Locate Comments for Drawing Sets/Specifications	H	6	6	6	
Provide Robust Clarity to Comments and Mark-ups (i.e. Attach Pictures)	H	6	6	6	
Ability to Create, Attach and Link RFI's w/ the Use of Plans and Specs	H	6	6	6	
Maintaining the Most To-Date Version of Drawing Sets and Specifications	H	6	6	6	
Navigation of Drawing Set - Page to Page (i.e. Search Drawing Set, Scrolling from Drawing to Drawing)	H	6	6	6	
Navigation of Drawing Set - Amongst Pages, Details, and Specifications (i.e. Locating details specific to a plan set)	H	6	6	6	
Navigation of Drawings - Single Page (i.e. Scrolling through a Drawing, Zooming In and Out)	H	6	6	6	
Recommendations for Improvements:					

Follow-Up Questions:

1.) Would you provide/perform drawing revisions and updates at a higher frequency with the use of the IT tool? (Y/N) YES

2.)Please, provide some features you would like to see incorporated into the IT tool used (improvements to IT tool)?

ABILITY TO USE A DIGITAL SIGNATURE, DYNAMIC DATE STAMP TOOL, THE ADDITION OF TEMPLATE FORMS AND PDF'S WOULD BE USEFUL.

3.) Do you feel there would be a measurable improvement in time savings due to the implementation of the IT tool? If yes, which alternative activities would this free up time for? If no, why not?

YES, IT ALSO ME TO SPEND MORE TIME IN THE FIELD AND LET'S ME COMMUNICATE WITH THE FIELD MORE TIMELY.

4.) Were there any specific major time losses caused by the use of the IT tool? What caused the time losses?

YES, LEARNING THE TOOLS AVAILABLE AND HOW TO MOST EFFECIENTLY MAKE USE OF THE TOOLS FOR SPECIFIC TASKS.

5.) How well did the IT tool fit into your current way of executing work? Did it require you to perform any extra steps or adjust your typical activities to use the software?

WORKED WELL, OVERALL REDUCED STEPS NEEDED. IT MATCHED MY CURRENT WORKFLOW IN THE OFFICE.

6.) Did it act as a sufficient or improved replacement for paper-based drawing sets?

IMPROVED REPLACEMENT FOR PAPER-BASED DRAWING SETS, ENCHANCED MY CURRENTLY ELECTRONIC WORKFLOW THAT I USE IN THE OFFICE.

7.) Was there any information you were not able to readily collect with the use of the IT tool that you normally capture with the use of standard hardcopy drawings and specs?

NONE

8.) Would you recommend the implementation of the IT tool full-time? (Y/N) Why?

YES, HAVING A MOBILE TOOL THAT CAN EFFECTIVELY CAPTURE THE DATA IN THE FIELD AND SHARE THAT DATA IMMEDIATELY GREATING IMPROVES THE FLOW OF COMMUNICATION ON THE PROJECT AND REDUCES THE TIME NEEDED TO PROCESS PAERWORK IN THE OFFCE.

Date: Company: Location: User #: Software:

Software Evaluation Sheet

Q1: How many years experience do you have in the industry? 5 years.

Q2: What is your current position? Project Engineer.

Q3: What is your experience level with tablet devices from 1 to 5 (Circle Answer)?
1 = Little/No Experience & 5 = High Level/Expert Experience

1 2 3 4 (5)

Q4: On average, how often do you utilize and mark-up drawing sets on a daily basis (Circle Answer)?

Less than once (1-3) 4-6 More than 6 times

Q5: Is a Stylus or Electronic Pen being utilized for this trial? (Circle Answer) YES (NO)

Fill in the tables below. The "Level of Importance" column indicates your opinion on how important that particular functionality or activity is in relation to your daily tasks; please indicate a low, medium or high level of importance. Use the Likert Scale (shown above each table) to rate the Information Technology's functionality in comparison to traditional paper-based methods:

1.) Field Trial 1 - Visibility

Task/Activity	Level of Importance (L/M/H)	Red-Lining IT Tool Compared to Traditional Paper Based Methods (Likert Scale 1-6)	Additional Comments
Effectively View Drawings - Field of View Constraints (i.e. Screen Size vs. Traditional 24" x 36" Drawing Sets)	H	6	
Visibility of Drawing Set Given Onsite Environment (i.e. Direct Sunlight)	H	5	
Recommendations for Improvements:			

2.) Field Trial 1 - Mobility

Task/Activity	Level of Importance (L/M/H)	Red-Lining IT Tool Compared to Traditional Paper Based Methods (Likert Scale 1-6)	Additional Comments
Mobility of Drawing Sets Around in the Field (i.e. Carrying Mobile Device vs. Traditional Drawing Sets)	H	6	
Recommendations for Improvements:			

3.) Field Trial 1 - Communication

Task/Activity	Level of Importance (L/M/H)	Red-Lining IT Tool Compared to Traditional Paper Based Methods (Likert Scale 1-6)			Additional Comments
		Time Spent Completing the Tasks	Simplicity of Completing the Task	Ability to Effectively Complete the Task	
Clarity/Distribution of Design Changes and As-Built Drawings with Comments, Mark-ups and etc.	H	6	6	6	
Clarity/Distribution of RFI's w/ the Use of Plans and Specs	H	6	6	6	
Access, Distribute and Maintain the Most To-Date Version of Drawing Sets	H	6	6	6	
Ability to Recall "Old" Mark-ups/Comments for Reference During Formal/Informal Meetings	H	6	6	6	
Recommendations for Improvements:					

4.) Field Trial 1 - IT Functionality

Task/Activity	Level of Importance (L/M/H)	Red-Lining IT Tool Compared to Traditional Paper Based Methods (Likert Scale 1-6)			Additional Comments
		Time Spent Completing the Tasks	Simplicity of Completing the Task	Ability to Effectively Complete the Task	
Ability to Redline and Effectively Mark-up/Highlight Items in Drawing Sets/Specifications	H	6	6	6	
Ability to Attach Comments to Drawing Sets/Specifications	H	6	6	6	
Ability to Define and Attach As-Built Information	H	6	6	6	
Alter/Remove Redlines and Comments in Drawing Sets/Specifications	H	6	6	6	
Ability to Sift Through and Locate Mark-ups/Highlighted Items for Drawings Sets/Specifications	H	6	6	6	
Ability to Sift Through and Locate Comments for Drawing Sets/Specifications	H	6	6	6	
Provide Robust Clarity to Comments and Mark-ups (i.e. Attach Pictures)	H	6	6	6	
Ability to Create, Attach and Link RFI's w/ the Use of Plans and Specs	H	6	6	6	
Maintaining the Most To-Date Version of Drawing Sets and Specifications	H	6	6	6	
Navigation of Drawing Set - Page to Page (i.e. Search Drawing Set, Scrolling from Drawing to Drawing)	H	6	6	6	
Navigation of Drawing Set - Amongst Pages, Details, and Specifications (i.e. Locating details specific to a plan set)	H	6	6	6	
Navigation of Drawings - Single Page (i.e. Scrolling through a Drawing, Zooming In and Out)	H	6	6	6	
Recommendations for Improvements:					

Follow-Up Questions:

1.) Would you provide/perform drawing revisions and updates at a higher frequency with the use of the IT tool? (Y/N)

Yes. Additionally, the frequency of revisions and updates would increase if the IT tool was mobile and did not need to be connected to an Internet source to perform the markups.

2.)Please, provide some features you would like to see incorporated into the IT tool used (improvements to IT tool)?

See Bluebeam Revu.

3.) Do you feel there would be a measurable improvement in time savings due to the implementation of the IT tool? If yes, which alternative activities would this free up time for? If no, why not?

Yes. Other project management functions, such as cost reporting, scheduling, submittal review, and site observation reports.

4.) Were there any specific major time losses caused by the use of the IT tool? What caused the time losses?

No. In fact, the use of an IT tool allows for better time management and increase productivity and accuracy of information.

5.) How well did the IT tool fit into your current way of executing work? Did it require you to perform any extra steps or adjust your typical activities to use the software?

Yes. As previously stated, I was able to perform job functions more accurately and efficiently.

6.) Did it act as a sufficient or improved replacement for paper-based drawing sets?

Yes. Having the IT tool with the record drawings and specs created efficiencies while performing job functions.

7.) Was there any information you were not able to readily collect with the use of the IT tool that you normally capture with the use of standard hardcopy drawings and specs?

No.

8.) Would you recommend the implementation of the IT tool full-time? (Y/N) Why?

Yes. Increased productivity and accuracy of project information.

Date: 08/21/2013 Company: [redacted] Location: San Antonio, Tx User #: Software: [redacted]

Software Evaluation Sheet

Q1: How many years experience do you have in the industry? 5

Q2: What is your current position? Field Engineer

Q3: What is your experience level with tablet devices from 1 to 5 (Circle Answer)?
1 = Little/No Experience & 5 = High Level/Expert Experience

1 (2) 3 4 5

Q4: On average, how often do you utilize and mark-up drawing sets on a daily basis (Circle Answer)?

Less than once (1-3) 4-6 More than 6 times

Q5: Is an Electronic Pen being utilized for this trial? (Circle Answer) YES (NO)

Fill in the tables below. The "Level of Importance" column indicates your opinion on how important that particular functionality or activity is in relation to your daily tasks; please indicate a low, medium or high level of importance. Use the Likert Scale (shown above each table) to rate the Information Technology's functionality in comparison to traditional paper-based methods:

1.) Field Trial 1 - Visibility

Task/Activity	Level of Importance (L/M/H)	Red-Lining IT Tool Compared to Traditional Paper Based Methods (Likert Scale 1-6)	Additional Comments
Effectively View Drawings - Field of View Constraints (i.e. Screen Size vs. Traditional 24" x 36" Drawing Sets)	H	5	IT IS EFFICIENT TO HAVE ACCESS TO ELECTRONIC DRAWINGS VS. PAPER DRAWINGS
Visibility of Drawing Set Given Onsite Environment (i.e. Direct Sunlight)	H	6	
Recommendations for Improvements:			

2.) Field Trial 1 - Mobility

Task/Activity	Level of Importance (L/M/H)	Red-Lining IT Tool Compared to Traditional Paper Based Methods (Likert Scale 1-6)	Additional Comments
Mobility of Drawing Sets Around in the Field (i.e. Carrying Mobile Device vs. Traditional Drawing Sets)	H	6	IT IS EFFICIENT TO HAVE ACCESS TO ELECTRONIC DRAWINGS VS. PAPER DRAWINGS
Recommendations for Improvements:			

3.) Field Trial 1 - Communication

Task/Activity	Level of Importance (L/M/H)	Red-Lining IT Tool Compared to Traditional Paper Based Methods (Likert Scale 1-6)			Additional Comments
		Time Spent Completing the Tasks	Simplicity of Completing the Task	Ability to Effectively Complete the Task	
Clarity/Distribution of Design Changes and As-Built Drawings with Comments, Mark-ups and etc.	H	5	5	6	
Clarity/Distribution of RFI's w/ the Use of Plans and Specs	H	5	5	6	
Access, Distribute and Maintain the Most To-Date Version of Drawing Sets	H	5	5	6	
Ability to Recall "Old" Mark-ups/Comments for Reference During Formal/Informal Meetings	M	4	4	5	
Recommendations for Improvements:					

4.) Field Trial 1 - IT Functionality

Task/Activity	Level of Importance (L/M/H)	Red-Lining IT Tool Compared to Traditional Paper Based Methods (Likert Scale 1-6)			Additional Comments
		Time Spent Completing the Tasks	Simplicity of Completing the Task	Ability to Effectively Complete the Task	
Ability to Redline and Effectively Mark-up/Highlight Items in Drawing Sets/Specifications	M	5	5	5	
Ability to Attach Comments to Drawing Sets/Specifications	M	5	5	5	
Ability to Define and Attach As-Built Information	M	5	5	5	
Alter/Remove Redlines and Comments in Drawing Sets/Specifications	M	5	5	5	
Ability to Sift Through and Locate Mark-ups/Highlighted Items for Drawings Sets/Specifications	M	5	5	5	
Ability to Sift Through and Locate Comments for Drawing Sets/Specifications	M	5	5	5	
Provide Robust Clarity to Comments and Mark-ups (i.e. Attach Pictures)	M	5	5	5	
Ability to Create, Attach and Link RFI's w/ the Use of Plans and Specs	M	5	5	5	
Maintaining the Most To-Date Version of Drawing Sets and Specifications	H	6	6	6	
Navigation of Drawing Set - Page to Page (i.e. Search Drawing Set, Scrolling from Drawing to Drawing)	H	6	6	6	
Navigation of Drawing Set - Amongst Pages, Details, and Specifications (i.e. Locating details specific to a plan set)	H	6	6	6	
Navigation of Drawings - Single Page (i.e. Scrolling through a Drawing, Zooming In and Out)	H	6	6	6	
Recommendations for Improvements:					

Follow-Up Questions:

1.) Would you provide/perform drawing revisions and updates at a higher frequency with the use of the IT tool? (Y/N) YES

2.)Please, provide some features you would like to see incorporated into the IT tool used (improvements to IT tool)?

ABILITY TO WRITE RFI'S IN THE FIELD AND ATTACH ANY NECESSARY DRAWINGS OR PARTIAL DRAWINGS. ALSO, TO HAVE ON FILE SHOP DRAWINGS AND RFI'S EASILY ACCESSIBLE.

3.) Do you feel there would be a measurable improvement in time savings due to the implementation of the IT tool? If yes, which alternative activities would this free up time for? If no, why not?

YES, IT FREE'S UP TIME TO FIND THE PAPER DRAWINGS AND PAGE THROUGH. IT ALSO HAS THE CAPABILITY TO ZOOM IN AND OUT FOR A CLOSER OR OVERALL VIEW.

4.) Were there any specific major time losses caused by the use of the IT tool? What caused the time losses?

YES, THERE IS A LEARNING CURVE AT THE BEGINNING. IT TAKES TIME TO LEARN HOW TO USE THE SYSTEM AND NAVIGATE. IT SAVES TIME IN THE LONG RUN THOUGH.

5.) How well did the IT tool fit into your current way of executing work? Did it require you to perform any extra steps or adjust your typical activities to use the software?

THE IT TOOL WORKED VERY WELL AFTER LEARNING HOW TO USE IT. IT SAVES STEPS.

6.) Did it act as a sufficient or improved replacement for paper-based drawing sets?

YES. I THINK OVER TIME MORE IT TOOLS WILL BE USED TO SAVE TIME.

7.) Was there any information you were not able to readily collect with the use of the IT tool that you normally capture with the use of standard hardcopy drawings and specs?

NO

8.) Would you recommend the implementation of the IT tool full-time? (Y/N) Why?

YES. OVERALL YOU ONLY NEED TO CARRY AN IPAD WITH STRAP AND THAT FREES UP YOUR HANDS FOR OTHER THINGS. ALSO YOU CAN TAKE A PICTURE AND UPLOAD TO THE DRAWINGS AND MAKE NOTES. YOU ARE NOT ABLE TO DO THIS WITH PAPER DRAWINGS AND YOU HAVE TO CARRY THEM AROUND ALONG WITH A SEPARATE CAMERA TO DO THE SAME THING THAT THE IPAD CAN DO WITH THE IT TOOL APPLICATION. OVERALL IT IS MORE EFFICIENT.

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